MINISTRY OF FUEL AND POWER

WHITEHAVEN "WILLIAM" COLLIERY, CUMBERLAND

FINAL REPORT

On the Causes of, and Circumstances attending, the Explosion which occurred at Whitehaven "William" Colliery, Cumberland, on the 15th August, 1947

By A. M. BRYAN, J.P., B.Sc., F.R.S.E.
H.M. Chief Inspector of Mines

Presented by the Minister of Fuel and Power to Parliament by Command of His Majesty June 1948

LONDON
HIS MAJESTY'S STATIONERY OFFICE
TWO SHILLINGS NET

Cmd. 7410

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THE RIGHT HONOURABLE HUGH GAITSKELL, C.B.E., M.P.,
Minister of Fuel and Power.

28th April, 1948

SIR,

EXPLOSION AT WHITEHAVEN "WILLIAM" PIT, CUMBERLAND

I.—INTRODUCTORY

1. In compliance with the direction of your predecessor in office, the Rt. Hon. Emanuel Shinwell, M.P., I have held a Formal Investigation under the provisions of Section 83 of the Coal Mines Act, 1911, and under the Ministry of Fuel and Power Act, 1945, into the causes of, and circumstances attending, the explosion at the Whitehaven "William" Pit, Cumberland, which occurred on the 15th August, 1947, causing the loss of 104 lives.

A list of the persons killed and injured is given in Appendix I.

2. Being in complete agreement with the unanimous opinion of the mining and other experts who gave evidence at the Inquiry, namely, that the explosion originated with the firing of a charge of sheathed permitted explosive placed in a shot-hole drilled in the roof, and directed towards the waste behind and immediately contiguous to a longwall face, and being apprehensive of the danger portending in other pits in the country where a similar practice existed, I deemed it necessary that the immediate attention of the managements at such collieries should be directed to the grave risks attending this practice. Accordingly, on the 15th October, 1947, I submitted to you an Interim Report in which I described very briefly the origin, cause and nature of the explosion, and made some suggestions and recommendations for the avoidance of a similar type of explosion in the future. The Interim Report was presented by you to Parliament on the 23rd October, 1947, and published as Cmd. 7236*.

3. The Interim Report was well received by the Mining Industry, and served its purpose in that it led to immediate steps being taken at many collieries to avert the danger envisaged. I have now the honour to submit my Final Report on the explosion.

4. The Inquiry was held in the Methodist Church Schoolroom, Whitehaven, from the 7th to the 10th October, 1947, inclusive. A list of the forty-six witnesses examined during the proceedings is given in Appendix II.

5. The appearances were as follows :—

(a) *Ministry of Fuel and Power :*

Mr. R. J. Edwards, H.M. Divisional Inspector of Mines, and
Mr. G. D. Nussey, H.M. District Inspector of Mines.
Dr. H. F. Coward, Director of Safety in Mines Research and Testing Branch.

(b) *National Coal Board :*

Mr. Paul E. Sandlands, K.C., and
Mr. G. R. Swanwick, instructed by Messrs. Brockbank, Helder & Ormrod, Whitehaven.

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* H.M.S.O. 1*d*.

(c) *National Union of Mineworkers :*
Mr. Abe Moffat and Mr. J. R. A. Machen.

(d) *Cumberland Area of National Union of Mineworkers :*
Mr. T. Stephenson, Mr. J. Martin and Mr. R. Beattie.

(e) *National Association of Colliery Managers :*
Major R. W.

(f) *National Association of Colliery Overmen, Deputies and Shot-Firers :*
Mr. B. Walsh, Mr. H. Skerry and Mr. F. Pattinson.

(g) *Association of Mining Electrical and Mechanical Engineers :*
Mr. S. A. Simon, M.A., and Mr. E. J. Westcott.

II.—PARTICULARS OF THE COLLIERY AND ITS BACKGROUND

(a) *General*

6. The " William " Pit is one of a group of pits sunk near the coast-line adjacent to the port and town of Whitehaven in the County of Cumberland. The pits in this group were sunk to work the rich seams of under-sea coal at the southern end of the Cumberland Coalfield. The " William " is situated on a ledge between the cliffs and the sea, 49 feet above sea level and 400 yards north of Whitehaven L.M.S. Railway Station. There are two circular shafts. The downcast shaft is 12 feet in diameter and is used for the winding of men, mineral and other materials. The upcast shaft, 14 feet in diameter, is a second means of egress and is not used for winding mineral. Both shafts were sunk about the year 1806 to the Six Quarters Seam at a depth of 891 feet. Many years ago, however, the lower length of the shafts was abandoned, and winding has since been carried on from an inset 30 feet below the Main Band Seam which is intersected by the shafts at a depth of 624 feet. There is, in addition, a third means of egress, by way of a roadway connecting the workings of the " William " Pit with the adjoining Haig Pit through the Wellington Pit, shown on Plan No. 1.

7. It is well to remember that this group of pits at Whitehaven, including the " William ", has had a somewhat chequered history in recent years in respect of ownership and a sombre record of disastrous explosions. In the past fifteen years ownership has changed no less than four times. In 1933 the Whitehaven Coal Company, Ltd., sold the pits to Messrs. Priestman Whitehaven Collieries, Ltd. In 1936, the pits were acquired by the Cumberland Coal Company (Whitehaven), Ltd. At this time the " William " had been standing idle for two years and was re-opened by the new Owners. With the nationalization of the coal mines, the ownership passed to the National Coal Board, and the " William " Pit became a unit in the No. 10 or Cumberland Area of the Northern Division of the Board.

8. So far as explosions are concerned, the group has probably the blackest record in the annals of coal mining. Since the advent of the present century, its record of explosions, involving the loss of ten or more lives, is as follows :—

Date	*Colliery*	*Persons Killed*
11th May, 1910	Wellington	136
5th September, 1922	Haig	39
12th February, 1928	Haig	13
29th January, 1931	Haig	27
3rd June, 1941	William	12
15th August, 1947	William	104

9. Nor is that all. The " William " Pit has a considerable history of trouble from heatings and fires due to spontaneous combustion. Indeed, the explosion in 1941 occurred in connexion with a large sealed off area of workings in the Main Band Seam, which had been abandoned in 1928 and in which at some time previously there was known to exist an active fire due to spontaneous combustion. There is an extensive area of abandoned bord and pillar workings in this 10 feet thick Main Band Seam, in which, although there had been much splitting and robbing of the pillars, there had been little " broken " working. In his Report* on this explosion, the late Mr. F. H. Wynne, C.B.E., B.Sc., stated : " Having regard to the thickness of the seam and the method of working, it is perhaps not surprising to find a history of trouble from time to time due to spontaneous combustion. Definite colliery records of trouble from this cause are, however, somewhat meagre and confined to comparatively recent years." Consideration of this present explosion, in some of its aspects at least, as well as of future precautions to be taken at the colliery, cannot be divorced from this background of explosions and fires.

(b) *Seams Worked and Method of Working*

10. Three of the principal seams, the Bannock Band, the Main Band and the Six Quarters, have been more or less extensively worked at the " William " Pit during its long history. As might be expected, the workings in the richest of them—the Main Band—are the most extensive. This seam lies about 25 fathoms below the Bannock Band and 42 fathoms above the Six Quarters Seam and was worked by the bord and pillar method. Largely because of the liability to spontaneous combustion which gave rise to heatings and fires which had to be sealed off, the seam was abandoned many years ago. From the re-opening of the pit in 1937 until June, 1941, the output came from longwall workings in the Bannock Band, but the workings in this seam were also sealed off and abandoned at that time, following the explosion which occurred in a sealed-off area of old workings in the Main Band Seam and which seriously affected the workings in the Bannock Band. Work was then started in the Six Quarters Seam from a cross-measures drift which had previously been driven to catch this seam. Thereafter it was from the Six Quarters Seam that practically the whole of the coal output since 1941 was obtained.

11. The Six Quarters Seam has an average thickness of 2 ft. 9 in. of clean coal with a volatile matter content of approximately 37 per cent. The floor is a fairly strong fireclay, and the immediate roof consists of 2 ft. of shale overlain by a band of coal 20 in. thick. Above this lies more shale until another thin seam of coal, with a fireclay floor, is reached, about 12 ft. up. The full dip of the seam is 1 in 10 in a westerly direction. The under-sea cover in the area concerned is about 120 fathoms.

12. The first districts to be developed and worked from the Six Quarters Drift were No. 1 South and what are now called the old Nos. 1 and 2 North Districts (*see* Plan No. 1). They were advancing machine-cut conveyor longwall faces. Old No. 2 District finished in 1946, but coal production in old No. 1 District continued until April, 1947. The dismantling of plant and withdrawal of materials from this district had not been completed at the date of the explosion. In the meantime, in anticipation of the decline of output from these districts and also in accordance with the general development plan for the working of the Six Quarters Seam, further development work was carried on seawards in a north-westerly direction. At the date of the explosion, the lay-out and full extent of the workings completed and still in progress in this area were as shown in

* Report on Explosion at the William Pit, Whitehaven Collieries, Cumberland, June, 1942 (Cmd. 6367) by F. H. Wynne, C.B.E., B.Sc.

Plan No. 2. These workings comprised No. 1 Rise, No. 2 Rise and No. 2 Dip District, all advancing double-unit longwall machine-cut conveyor faces; the continuation of No. 3 Trunk Road known as Skelly's Heading; a Shortwall Face known as No. 1 Dip off No. 3 Trunk Road; the Back-End Shortwall Face; No. 2 Dip Heading (Allen's Dr ft), which had been dr ven in stone to connect with the seam on the inbye side of a fault; and, finally, Brannon's Heading, which was being driven in coal from No. 2 Dip Heading to connect with the return airway from No. 2 Dip Longwall. Except for No. 1 Rise District which had ceased production in January, 1947, on striking a fault, work was proceeding in all of these places at the date of the explosion. Because of faulted ground, the left face of No. 1 Rise District lagged considerably behind the right side face.

13. With the exception of No. 2 Dip Heading (Allen's Drift), in which pneumatic picks were used in coal-getting, all coal was undercut by compressed-air driven chain coal-cutting machines, the machine employed on the No. 2 Dip face being fitted for wet-cutting. The coal was transported from the faces by conveyors to a central loading point near the outbye end of No. 3 Trunk Road beyond its junction with No. 2 Dip Trunk Road. The face and inbye gate conveyors were operated by compressed-air, while the main trunk belt conveyors were electrically driven. From the central loading point the coal was taken in 10 cwt. capacity hutches by under-rope endless haulage to the shaft fully two miles outbye, by way of the main intake airway.

14. Shot-firing was practised in the coal on all faces, in the rippings or brushings and, on the No. 2 Dip face at least, also in the roof along the face opposite the wastes, in order to get stone for strip packs. The shot-holes were bored by compressed-air driven rotary drills. Permitted sheathed explosive (Polar Ajax) and sand-clay stemming were used throughout.

15. The method of roof support on roadways was mainly by steel arches, while wood props and lids were used at the actual working face. The system of support and roof control on the No. 2 Dip double-unit longwall face—the face on which the explosion started—consisted of wood props and lids at the coal face, roadside packs along the gateways and strip packs of varying widths built in the wastes and having between them varying widths of wastes, opposite which wood chocks were set.

(c) *Underground Lighting*

16. The types of lamp provided for general use underground were Ceag 2·5-volt Alkaline Superlite electric cap lamps, with ordinary Protector flame safety lamps for gas detection by the workmen where required by the General Regulations, and Protector No. 6 flame safety lamps for the officials. In addition, six Nife 2·5-volt Alkaline cap lamps were in use. Fixed electric lights from the mains were also provided at the central loading point and at certain parts of the main haulage road.

(d) *Ventilation*

17. The main ventilation was produced by a steam-driven Walker Indestructible fan placed near the top of the upcast shaft. The fan, erected in 1903, was said to be designed to pass 150,000 cub. ft. of air per minute with an 8 in. water-gauge when running at 275 revolutions per minute. An air measurement taken in the fan drift some weeks before the explosion showed that approximately 60,000 cub. ft. of air per minute was passing with the fan running at 240 revolutions per minute, with a water-gauge of 5·8 in. The general direction of the ventilation, the air splits and the quantities passing at various points as recorded in the air measurement book for the month of July,

and the firedamp content of the air at several points in the circuit, as revealed by analyses of air samples taken shortly before the explosion, are shown in Plan No. 1.

18. It will be seen from Plans Nos. 1 and 2 that the intake air was split at No. 3 Junction. The air in the rise split travelled inbye along No. 3 Trunk Road and was coursed round No. 1 Dip Shortwall face, and the left and right faces of No. 2 Rise District, before passing to the return airway. The air in the second split passed part way along No. 2 Dip Trunk Road and was coursed around No. 2 Dip Face, entered the Back-End Shortwall from No. 2 Dip Heading and then passed to the main return by way of an overcast over No. 3 Trunk Road. The face of No. 2 Dip Heading (Allen's Drift) was ventilated by fresh intake air by means of two small compressed-air driven auxiliary fans placed in series inside tubing, the outer length of which passed through the three brattice doors on No. 2 Dip Trunk Road. A second air-crossing at the junction of the return from the No. 1 Dip Shortwall Face with No. 3 Trunk Road was due to be completed on the night of the explosion, with a view to providing a separate ventilation split for this face.

(e) Output and Persons Employed

19. During the three months prior to the explosion, the output of the colliery was just over 2,000 tons per week. In addition to normal coal production, a considerable amount of development and repair work was also being done at this pit. Work was organized on three shifts. Coal filling, haulage and coal winding were done on the day-shift, pan-shifting, brushing and packing, and coal cutting on the back-shift, and back brushing and general repairs on the night-shift. The normal complement of workmen on the three shifts was 177, 159 and 104 persons, respectively. On the 15th August, the day of the explosion, 166 persons had been working underground on the day-shift and 133 persons on the back-shift—the shift on which the explosion occurred. Of these back-shift workmen, however, 14 persons were on a "staggered" shift and had all ascended the shaft by 5.40 p.m. and, because of illness, another back-shift worker had also ascended by that time. This left 118 persons underground at the actual time of the explosion.

(f) Management of the Mine

20. The mine was under the daily supervision of Mr. W. H. McAllister who, after being Under-Manager at the colliery for over 3 years, was promoted to be Manager, in November, 1946. To assist him he had one senior oversman on the day-shift, a back-shift oversman, three sectional oversmen, an official designated as a ventilation engineer, and a number of deputies and shot-firers. The Manager was supervised by a Colliery Group Agent, Mr. D. McPherson, who, in turn, came under the direction of the Area General Manager for Cumberland, Mr. J. G. Helps, and of a Deputy Production Director for the Division, Mr. J. A. Nimmo. The Agent, Mr. McPherson, had taken up his duties at the end of March, 1947, in succession to Mr. A. B. MacDonald, the former General Manager of the Cumberland Coal Co. (Whitehaven) Ltd., while Mr. Helps and Mr. Nimmo commenced their supervisory duties at the William Pit on 1st January, 1947, on the advent of Nationalization.

(g) Precautions Against Coal Dust

21. Suitable arrangements were made to meet the requirements of the General Regulations in respect of precautions against coal dust. The roadways were apportioned in numbered zones to enable systematic cleaning-up, stone-dusting and sampling to be done. Several persons were employed daily in cleaning-up dust accumulations, special attention being given to conveyor transfer and

loading points. The duties of the "ventilation engineer" included the supervision of this work, the collection of the necessary samples for analysis, and the recording of the required information in the prescribed book. Contrary to the statutory requirements, dust samples were not collected during the month of July. About 3½ lb. of stone dust per ton of coal output were used underground for stone-dusting on roadways and before shot-firing. The incombustible dust used was produced from limestone obtained from quarries in Cumberland. The results of the analyses of roadway dust samples collected after the explosion and over a period of months before the explosion showed that, on the whole, stone-dusting had been satisfactory from the view-point of the standard laid down by the Regulations. So far as the coal face was concerned, the longwall coal cutter working on the face in the No. 2 Dip District was fitted for wet cutting and there was little evidence of coal dust to be seen on the face in this district.

III.—NARRATIVE OF THE EXPLOSION

(a) Discovery and Preliminary Attempts at Rescue

22. The explosion occurred at 5.40 p.m. on the 15th August, 1947, when 118 persons were at work underground on the back-shift. There were only 14 survivors. Eleven of these, including onsetters, haulage hands and three repairers, were at work on the outbye side of the area seriously affected by the explosion at points ranging from the downcast pit bottom to a point fully a mile inbye on the main intake haulage road where the three repairers were engaged in renewing steel arches. Of these eleven persons, only one was injured—a repairer, who was taken to hospital as a result of slight injuries sustained when he was blown off the barrel on which he was standing when the explosion happened. The remaining three survivors, who were working at the face of No. 2 Rise District on the inbye side of the area traversed by the explosion, had a miraculous escape, and were brought to the surface in a somewhat exhausted condition on the afternoon of the following day. A fuller reference to their remarkable escape will be given later. The probable disposition, immediately prior to the explosion, of the 104 persons who lost their lives and of the three facemen who survived, is shown in Plan No. 2.

23. There was nothing in the events prior to the explosion which had given the management cause for worry or alarm. For some considerable time, work had been proceeding quite normally. Nothing untoward had happened, had been observed or had been reported that indicated danger, let alone an impending disaster of great magnitude. The work of the day-shift on the 15th August had been completed without incident; the back-shift workers had gone down to work at their allotted tasks; the 14 persons on the "staggered" shift had completed their day's work and had ascended the mine about 5.30 p.m. with no hint of anything out of the ordinary; and, lastly, a sick back-shift worker ascended about 5.35 p.m. About 5 minutes later came the first warning of the explosion. The onsetter felt a "rush of wind" coming from inbye which raised the dust, and, although the blast was quite strong, it did not knock him over. He knew at once that something serious had happened, and immediately telephoned to bank. He then went 100 yards along the siding to the pit circuit telephone where he found a haulage hand trying to telephone inbye without result.

24. The Manager, Mr. W. H. McAllister, had left the colliery a few minutes before the warning was received at the surface, and on reaching home received an urgent message to return to the pit at once. He did so and arrived back about 6 p.m. All the information he could then get was that "something had

happened underground." On his way to the shaft he met the surface compressor attendant, who told him the compressor was running at full speed and he thought there must be "an open end somewhere." After instructing the attendant to keep the compressor running until he received further instructions, Mr. McAllister descended the shaft. He was not long in coming to the conclusion that there had been an explosion, and he immediately telephoned to the surface for urgent messages to be sent to all his superior officers, H.M. Inspector of Mines, representatives of the National Union of Mineworkers, the Rescue Station, the Chief Engineer and Electrician and two local Doctors. All responded to the call without delay.

25. The Manager then went inbye along the main intake road to explore, taking a few workmen with him. He had not gone very far when he noticed a peculiar smell which, from previous experience, he associated immediately with an explosion. On reaching the air crossing from the Six-Quarters Seam to the main return in the Main Band Seam (Plan No. 1) he sent two workmen in to examine the doors and the state of the air in the return, with a view to reaching two repairers, Fox and Marshall, who were working in the main return. They reported the doors intact, the air deadly, and any attempt at rescue impossible. Two workmen were at once sent to the shaft to bring in canaries and a portable reviving apparatus. The remainder of the party proceeded inbye. The separation doors in the first connexion between intake and return in the Six Quarters Seam were found intact, but from this point inbye signs of explosive violence became more evident, and the smell in the atmosphere more noticeable. The party pressed on. When the junction of Old No. 2 North was reached, they found tubs derailed, roof girders displaced and the roof weighting badly. After setting some workmen on to strengthen the roof supports the party pressed on again but found the roadway dangerous because of numerous falls. The party then returned to the junction of Old No. 2 North District and found intake air entering it. This roadway had been previously sealed off by a brick stopping with two half-doors in it. On the inbye side of the brick stopping there was a wooden "clincher" stopping with a sheet in it. At the air-crossing itself, there were two doors leading into the main return. One was blown off and the other blown open and damaged. The return airway was heavily fouled with deadly afterdamp. Returning to the junction the party tried to get further inbye along the main intake, but after travelling a few yards beyond the point reached on their first exploration they were forced to abandon the attempt because of heavy falls and roof weighting. About this time the Agent, Mr. D. McPherson, and the Chief Planning Engineer, Mr. A. B. Dawson, arrived with canaries, followed soon after by the first Mines Rescue Team. The canaries were tried in the return airway and immediately collapsed. Because of falls and dangerous roof conditions, no further exploration was possible by the main intake and haulage road until repairs had been effected and the ventilation restored. And since the only possible approach to the inbye workings was by way of the return airway, which was fouled by the poisonous afterdamp of the explosion, thereafter, until the ventilation was restored, all exploration and recovery work was done by fully equipped rescue teams.

(b) *Work of Trained Rescue Brigades*

26. With the arrival of Superintendent Charlton and the three permanent rescue corps men, bringing with them the necessary equipment from the Cumberland Central Rescue Station at Brigham, and of trained rescue men from the Whitehaven and other collieries in the Cumberland coalfield, rescue and recovery work was set in motion without delay about 7 p.m. on the night of the explosion. From the preliminary reports of the first rescue teams in action it very soon became evident that a disaster of appalling magnitude had

occurred and that there seemed little hope of rescuing anyone alive. Moreover, because of the heavy death roll and the long distance to be travelled by the teams in roadways full of noxious gases and badly obstructed by falls, damaged plant and machinery, it also became apparent that, if the exploration and recovery work was to be carried out expeditiously, more trained rescue men would be needed than the Cumberland coalfield could supply. Accordingly, teams were brought from Durham and Northumberland Stations that night under the charge of Chief Officer Mills, who then took charge of operations. Later, assistance and equipment were also received from the Boothstown Rescue Station in Lancashire, and the Coatbridge Rescue Station in Scotland. In all, 35 teams took part in the operation—probably the largest number ever engaged on this work at a colliery—making 105 underground visits, 75 of which were made by the 14 regular Cumberland teams. As was to be expected, they did magnificent work under arduous and dangerous conditions but, despite their numbers, the strain during the first two days was too heavy and a break in the work had to be enforced at the week-end to give the men a much-needed and well-earned rest. Certain matters in connexion with the organization and arising out of the work of the trained Rescue Brigades will be discussed later.

27. All the reports of rescue teams for the period covering the night of the explosion and the following morning, relative to the conditions prevailing in the inbye workings of the Six Quarters Seam, gave no grounds for hope that any of the missing men could possibly be alive. During this period the rescue teams were operating from a fresh-air base in Old No. 2, adjacent to the air crossing. At first their work was confined to exploration in the hope of finding someone alive. As more trained rescue teams became available, some teams were detailed to recover bodies of victims ; but the work of exploration still went on. It came, therefore, as a tremendous surprise when, in the early afternoon of the 16th August—fully 20 hours after the explosion—three men, J. E. Birkett, D. Hinde and J. J. Weighman, suddenly made their appearance in the main haulage road. Hopes were immediately revived that others might still be alive. About this time, the fresh-air base was advanced inbye to No. 3 Trunk Road, and every available rescue team put on to explore every part of the inbye workings which was not so obstructed as to prevent entry. With the advance of the fresh-air base, the shorter distances now to be travelled made the journey to the inbye workings practicable in the limited time during which the teams could operate beyond their base. But no further signs of life were found. Except for the rest period already mentioned on the night of the 17th/18th, the trained rescue teams continued their labours until the recovery of the last body from the pit at 9 p.m. on the 23rd August.

(c) *Exploration of the Explosion Area*

28. Concurrently with the work of the trained rescue teams, who entered the inbye workings by way of the return airway, relays of workmen and officials worked continuously on the main haulage road in fresh intake air, clearing falls, setting supports and restoring the ventilation. Despite their efforts, it was not until the 27th August, nearly twelve days after the explosion, that it became possible to make a complete inspection of the whole of the inbye workings traversed by the explosion.

29. As the ventilation and travelling
and faces traversed by the explosion were restored, investigations extending over many days were made by H.M. Inspectors, members of staff of the Ministry's Safety in Mines Research and Testing Branch, colliery officials and other representatives of the National Coal Board, and by representatives of the workmen. There was evidence of violence in many places. The position of the bodies as located by the rescue teams and the condition and location of all

plant and machinery, of falls and other relevant matters were carefully noted and are shown in some detail in Plan No. 3. Indications of direction of force as shown by the displacement of stoppings, tubs, supports, plant and other movable objects were carefully noted and recorded. I personally made two underground inspections of the scene of the disaster, accompanied by representatives of the Inspectorate, Management and workmen.

(*d*) *The Story of the Three Survivors*

30. On the day of the explosion, Birkett and Hinde, both brushers, descended the mine at 2.30 p.m., while Weighman, a pan-shifter, descended at 1.30 p.m. They were at their work in the No. 2 Rise District, when the explosion happened. All three—the " three living miracles " as they were called by Mr. Abe Moffat of the National Union of Mineworkers—gave evidence at the Inquiry and had a remarkable story to tell. Each told of his unique experience very impressively, so much so, that I think it right to quote Birkett's own dramatic words from the transcription of the official short-hand notes :—

" *Examination of Mr. J. E. Birkett by Mr. Edwards* "

Q.—You were on this job round about 5.30 or just after ? *A.*—Yes.

Q.—What happened at the time ? *A.*—There was 12 of us together working round where I was, and there was a terrible report.

Q.—One ? *A.*—One.

Q.—Yes. *A.*—Just as if the drums of our ears had burst, it was that severe, and the air like fluttered, and when it was over everyone said they thought the drums of their ears were going to burst. A chap called Clark, and Hewer—he was acting overman—thought it was the short wall face had collapsed. So Clark says " Come on, we will go and see Joe ", he said " we will go and see if it has collapsed ". So they went away, and two or three minutes after I says " I will go and get my bait ", but when I got about 10 yards up the face someone shouts " Hurry up, come on ". When we got up and off the face into the mothergate, we put our clothes on and at the four road ends we were all congregating there when I heard Clark say to Hewer " Hurry up Joe, and get on the face and see what is wrong ". Nicholson, the deputy, says " Are we all here ? ". I said " Yes ", and he says " Follow me ". We set off to go out. When we got so far by one dip air crossing just up there it was terrible thick, and the deputy started to go down and one or two more, and as he was going down someone asked for an oil lamp. I asked him if he had put his out or had it gone out, and he said he put it out. Then an oil lamp came into my hands, where from I don't know. With that someone says " This door's open "—that was in the air crossing, and that is only a small door. The men started to go in it. Of course being very small at that time you would have thought they were crushing. They were a shade and I turned and said " Don't panic men ". When we got in it was red hot. I took my coat off and threw it away, and next thing was Jimmy Rigg says " Can we not get down here Jack "—that is down by one dip tail-gate round by this face—" and get out ". I says " No, we are going to face it all the way ". With that I says to Hinde " Can you tell me where there is any water ? ", and he says " Main end ". I says " Come on in here . . . . "

Q.—Meaning Skelly's ? *A.*—Yes. Skelly's. As I was going I asked a chap to come, but someone shouted to him and he didn't. Why we will never know. As Hinde and I were going down into the end we heard Weighman's voice. He asked if that was Jack and I said " Yes, and Danny ". As we were crawling down I says to Hinde " I am not going to make it ". He said " Try Jack ".

I says " I am not going to make it ", so he shouted to Weighman and they came and pulled me out down by the loader end into the end. I laid face down for a long time. When my heart became normal and my head stopped throbbing I said to Hinde and Weighman, I said " God is good, we will get out of here." I asked them what water we had, they said two bottles. I said " Don't drink it ". I saw what bait I had and had a little bit. They had theirs and after the bait they said " What about having a go ". I says to Weighman " You take the lamp, Jimmy ". I had the . . . .

Q.—You are referring to the oil lamp ? *A.*—Yes. I says " You take the oil lamp ". I had a hawk, and I said " Danny, bring the water "—the two bottles like. So we tried. When we got about 20 or 30 yards inbye that crossing we had to retreat again. We went back and tried two or three times.

Q.—Was the atmosphere stuffy ? *A.*—Yes, it was bad.

Q.—It was smoky ? *A.*—It was bad. When we were lying, I do not know what time it would be, Hinde says " They are a long time of coming, Jack ", and I said " Yes ", but he said " There must be a big fall ". I said " There must be ". I said " If they have to come from the pit bottom they will hurry, and we will get out as fast as possible ". I said " God is good and we will get out ". While we were lying there Hinde says " Jack, look at this lamp ". I looked and gas was right up the barrel, so we decided to have another go. We set off again and when we got to the brow top the lamp went out. He says to me " What are we going to do ? " I said " If we go back there we have had it ". I said " If we go on we have a chance of getting out or else we go under ". I had a scarf round my neck, and asked Hinde to wet it, which he did. I asked them if they had a scarf and they said " No ". I said " Take a stocking off ", and Hinde tore his shirt, and Weightman took his vest off. We wet them and set off out. As we were passing the dead, Weighman felt one of their arms, but before we went I said to Jimmy " Click Nichy's oil lamp ". He got that oil lamp and we got out to the second air crossing.

Q.—That is the second oil lamp ? *A.*—Yes. We got to the crossing and when we got on the top Hinde said " There is a light here ", and I said " We don't want that ", and then Hinde said " There is air coming up here ". I said " That is where we want to be ". As we were going down Hinde said " This is better than winning the Irish Sweep ". We travelled out right to the entrance of No. 3. As we were going up the main road and got so far I said " For a pipe a minute, we want another minute " and had another. As we came to each fall we went over the top until we came to the last one outbye. We got to there and we could hear knocking. I said " Wait a minute ". I knocked on the plate but they could not hear. I said " Come on Jimmy, over the top ", and as we were going up I says " Hello ". From when we got on the top we saw men. That is it.

Q.—You had no idea of the time or anything ? *A.*—Nothing.

31. Hinde and Weighman told equally human and dramatic stories, confirming what Birkett had said. Despite their terrifying ordeal in the inbye workings and their labours in scrambling over the numerous falls on the main haulage road on their way outbye, the three men were cheerful and in surprisingly good condition when they reached the workmen engaged in repair work at the outbye end of the fallen roadway. The survivors, after receiving the necessary attention, were then brought to the surface and removed to hospital. A day there and a short holiday soon restored them to normal health. All three showed remarkable presence of mind in a serious emergency and displayed considerable moral courage and a high sense of judgment in weighing up the possibilities and deciding to retreat to the inbye workings rather than make a rash bid for safety

by rushing outbye. They again showed their good judgment by their decision to make their way outbye at the time they did. Altogether their conduct was worthy of high praise. I have already brought this matter to your notice with a view to its appropriate recognition.

(e) The Use of Trained Dogs

32. It is of special interest to record that dogs were used underground in a coal mine for the first time in an attempt to locate bodies buried under falls. This suggestion, first made by Mr. I. G. E. Leek, H.M. Inspector of Mines and Rescue Apparatus Testing Officer, was at once accepted by the respresentatives of all parties. Mr. Leek thereupon telephoned the R.A.F. Police Dog Training School at Staverton. The Provost Marshall immediately granted permission and forthwith dispatched in a truck F/Lt. Cooper and two Corporals, Marshall and Jenkins, in charge of two trained police dogs, " Rex " and " Prince ". Unfortunately dogs trained in body recovery work were not available. Later the party was joined by Corporal Darnall. Another dog, " Jet ", was collected from its owner on the journey north. " Jet " had done a lot of body recovery work during the London air raids but had been back with his owner as a pet for nearly two years. A training gallery was hurriedly prepared at the pit top, where the dogs were given a little practice before being taken down the pit.

33. Although none of the men in charge of the dogs had ever been down a mine, they never hesitated for a moment when asked to do so. For these men to go underground for the first time and do a job of work under the conditions then prevailing in the William Pit required " guts " of a high order. In spite of the handicaps of lack of training in body recovery work and of working in very strange conditions, the dogs were considered to have done useful work. It was thought for several days that a missing haulage hand would be found beneath one of several large falls on the main haulage road. The dogs worked these falls several times but showed little interest in any particular place, and rightly so, because eventually one of the mutilated bodies previously found was identified as the missing man. By this time only two bodies were missing. Although there was little doubt as to which large fall these bodies were under, nevertheless those on the spot were agreed that the dogs, after working the falls, were valuable in giving an indication as to the position of the bodies within the fall.

34. I consider this unique trial indicated that dogs properly trained for body recovery work in mines might well give valuable assistance in locating bodies buried under falls and that the use of trained dogs is well worthy of further consideration and trial.

IV.—THE PLACE OF ORIGIN AND CAUSE OF THE EXPLOSION

(a) The Place of Origin and Source of Ignition

35. There was complete agreement among all the mining engineers and other expert witnesses at the Inquiry as to the place of origin and cause of the explosion. Following upon careful investigations underground and their consideration of all relevant factors, such as signs of violence, direction of force, condition and position of bodies, nature of the work being done at the time and probable or possible sources of ignition in relation to the possibility of the presence of an inflammable or explosive atmosphere at the site of a suspected source of ignition, the expert witnesses were unanimous that :—

(*a*) the explosion started on the No. 2 Dip Longwall Face ;

(*b*) it originated with the firing of a charge of sheathed permitted explosive placed in a rising shot-hole drilled in the roof between the coal-face and the waste and directed towards the waste ;

(*c*) the shot-hole passed through a roof break and the inner end of it either made contact with, or was in very close proximinity to, a bed separation cavity ;

(*d*) this cavity contained an accumulation of inflammable gas which was continuous with a larger accumulation of explosive gas in the waste ;

(*e*) the firing of the shot ignited the gas in the bed-separation cavity and the gas burned for a short interval of time before the flame reached the larger accumulation of gas which exploded violently ; and

(*f*) the explosion, once started, traversed a considerable area of working faces and roadways before it was finally arrested, due to lack of fuel, a considerable distance from the point of origin.

36. Having first satisfied myself that all other possible sources of ignition could be eliminated, I had no hesitation whatsoever in coming to the same conclusions.

(*b*) *Other Possible Sources of Ignition*

37. The other possible sources were : defective flame or electric safety lamps ; electrically operated machinery, cables and switch-gear ; compressed-air plant and accessories ; signalling apparatus ; magneto exploder ; and frictional heating or sparking. Following a careful and expert examination of all these possibilities, the only potential source of ignition of an inflammable firedamp-air mixture discovered was a patched compressed-air hose which showed definite signs of burning at the patch. But since this piece of hose was lying on the floor near the face end of the mothergate in No. 2 Dip Face, it was inconceivable that it could have been in direct contact with an inflammable firedamp-air mixture at the time the explosion happened. It was therefore ruled out as a possibility in this explosion.

38. Nevertheless, as this potential igniting source is liable to be overlooked at collieries, I think it necessary and advisable to draw attention to this possible danger and to indicate how the danger arises. For examination and test, an 8-in. length of the 2-in. diameter hose containing the patched puncture, together with a piece of sacking folded to give four thicknesses, which was strapped over the puncture, were sent to the Ministry's Research Laboratories at Buxton. Examination of the wall of the hose at the puncture showed unmistakeable signs of burning of the cotton reinforcing, while one edge of the sacking also showed signs of burning. Further, the imprint of the patch could clearly be seen on the hose, while the recovered patch was about one inch shorter than the imprint. Presumably the remainder had been burnt away. Comparison with previous experiments indicated that this puncture had been a " squealing " leak and that the heating had been caused by internal friction. Further examination showed that the puncturing of the hose caused tearing of the inside surface, the tears radiating from the puncture and leaving tongues of rubber and reinforcement. It was concluded that the escape of air caused these to vibrate at a high frequency, giving rise to some heat due to friction at external rubbing surfaces, but even more due to internal friction of the tongues as they stretched and bent. It was suggested that the cotton reinforcing had then disintegrated and part of it scattered as sparks which were capable of igniting an inflammable firedamp-air mixture, or, if they fell on suitable combustible material, of starting a fire. There seemed little doubt in this case that they caused either the smouldering or burning of the sacking wrapper. Clearly, an improperly patched puncture in a compressed-air hose is a potential source of

gnition and a positive danger if such hose is used in any part of a mine where t may be in contact with combustible matter or inflammable gases. I should add that attention has already been drawn to this danger in the Twenty-third Annual Report of the Safety in Mines Research Board (1944) and in a letter from Dr. H. F. Coward, the Director of Research, published in the " Colliery Guardian " and " Iron and Coal Trades Review ", on 24th June, 1944.

(c) *Operations on No. 2 Dip Face*

39. Since it was abundantly clear from the evidence that no suspicion attached to any part of the mine other than the No. 2 Dip Face, it is necessary only to describe the work being done on this face immediately prior to the explosion in order to get a picture of what happened. There were no survivors from this face but, so far as could be ascertained, the work in progress on the face that afternoon included (i) the ripping and packing of the mothergate, (ii) the undercutting of the coal face, (iii) pipe-shifting on the right-side face, (iv) advancement of the face chocks and of the conveyors on both left-side and right-side faces, and (v) the advancement of the strip packs on both sides of the face using stone obtained from the waste. From the position of the bodies and the state of progress of the work up to the moment of the explosion, it is clear that the work had been proceeding at the normal rate, and that the job of pipe-shifting had been completed, for the fitters by this time had left the face. Since all the expert witnesses were agreed that the explosion originated with shot-firing, only this aspect of the work on this face need now be considered in detail.

(d) *Shot-firing on No. 2 Dip Face*

40. Investigation showed that eleven shots, charged with a sheathed permitted explosive, Polar Ajax, had been fired by deputy Murtagh on No. 2 Dip Face that afternoon, as follows :—

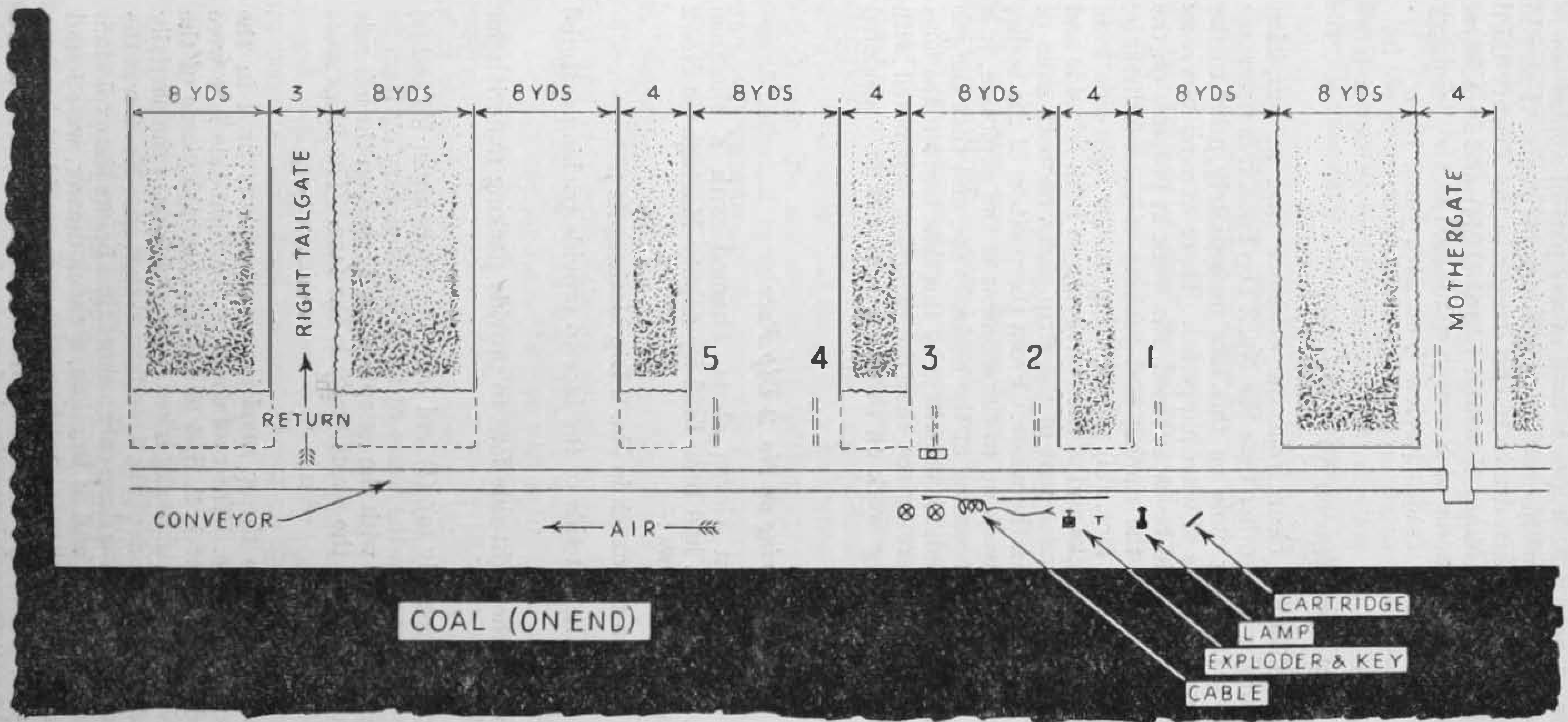
(*a*) four ripping shots in the canch in No. 2 Dip Mothergate ;

(*b*) two roof shots on the left side of the face to provide packing material for strip packs ; and

(*c*) five roof shots on the right-side face to provide packing materials for strip packs.

The order of firing was probably (*a*), (*b*) and (*c*). The shots under (*b*) and (*c*) were bored from the face towards the waste at an inclination varying from 20 to 25 degrees to the plane of roof, with the exception of one shot on the left-side face which had been bored from the waste towards the face. The holes were from 3 ft. 6 in. to 4 ft. long.

41. There was no evidence to throw suspicion on the shots fired in the mothergate or in the left-side face. The roof shots on the right-side face were almost certainly fired in the order 1, 2, 5, 4 and 3 (*see* Fig. 1). Some of the material from shots Nos. 1 and 2 had been packed. The positions of the partially coiled firing cable and of the exploder (Fig. 1) indicated that shot No. 3 was the last shot to be fired and that this was done only a short time before the explosion. The bodies of shot-firer Murtagh, and of Brannon, a chock-drawer, were found lying opposite this shot-hole. Both men died from carbon monoxide poisoning ; but whereas Murtagh showed no sign of external injuries, Brannon had sustained a fractured skull and a severe neck laceration before death.



PLAN OF No. 2 DIP RIGHT HAND FACE

SHOWING THE POSITIONS OF THE SHOTHOLES

Fig. 1

42. In explanation of this, Mr. G. D. Nussey, H.M. District Inspector of Mines, suggested that when Murtagh was ready to fire shot No. 3, he sent Brannon down the face to prevent anyone approaching the shot from the direction of the right tail-gate while he went up towards the mothergate to fire the shot and guard the approach from that side ; that when the shot was fired Brannon was struck by a stone projected from the shot and had then immediately moved towards Murtagh who, having just detached the cable from the exploder (and probably also heard a shout from Brannon) moved down towards him ; and that when they met nearly opposite the shot-hole, the explosion happened. Another explanation suggested was that immediately the shot was fired, both men saw some indication of flame, that both made towards the shot-hole to see what had happened, that when they met near the hole the explosion occurred and that Brannon was then struck by some missile projected by the explosion. But whatever the sequence of events, it is clear that there must have been a short interval of time between the firing of shot No. 3 and the actual explosion.

(*e*) *Detailed Examination of Shot-holes*

43. Careful examination revealed no dangerous features associated with shot-holes 1, 2 and 5. These shots were therefore ruled out as possible causes of delayed ignition. Observations made with regard to shot-holes 3 and 4 make it desirable to describe each in some detail.

44. The conditions of shot-hole No. 4, as noted by Drs. Grimshaw, Shepherd and Phillips of the Ministry's Safety in Mines Research Branch on 1st September, are illustrated in Fig. 2. An almost continuous trace, AB of the upper surface of the hole was left on the roof for a distance of about 3 ft. 6 in. At CE a further trace of about 6 in. of the lower surface was observed on a ledge of roof bordering a cavity in a shatter zone caused by the shot. Starting at a point about 5 in. from B and going towards A, there were indications of clay stemming. From this it was assumed that the remaining 11 in. of hole contained the explosive. This length represented two 4 oz. cartridges. The explosive, clearly, had not expended its full energy in breaking down the roof bed, but had partly expended itself in producing the shattering observed beyond the above points B and C, resulting in a cavity extending upwards to the coal bed above the immediate shale roof.

45. It was estimated that there was about 2 in. of shale between the end of the shot-hole as bored and the immediate roof bed. There was also a pronounced opening along the bedding plane between the shale roof and the coal above—a condition that almost certainly existed when the shot was fired, for otherwise it would be difficult to explain the upward shattering effect. There is no reason to suppose that the 2 in. thickness of shale between the end of the hole and the bed separation cavity was broken before the shot. Experimental work at the Buxton Research Station has indicated that when a charge is fired in a hole which runs towards an opening containing an inflammable mixture of firedamp and air, a barrier of 2 in. of solid material (e.g. of stone or a plug of clay) renders ignition very improbable. The proximity of the hole to the parting above, therefore, constituted the only possibly dangerous feature of this shot. A sample of the atmosphere at point S1, taken through a metal tube inserted for a distance of 2 ft. 6 in. into the bed separation cavity showed on analyses : 71·7 per cent. Methane ; 7·05 per cent. Carbon Dioxide and 3·67 per cent. Oxygen.

46. The conditions noted by the same three observers at shot-hole No. 3 are illustrated in Fig. 3. This hole was bored immediately over a prop and the length AB was left more or less intact and partly filled with loose stones. The

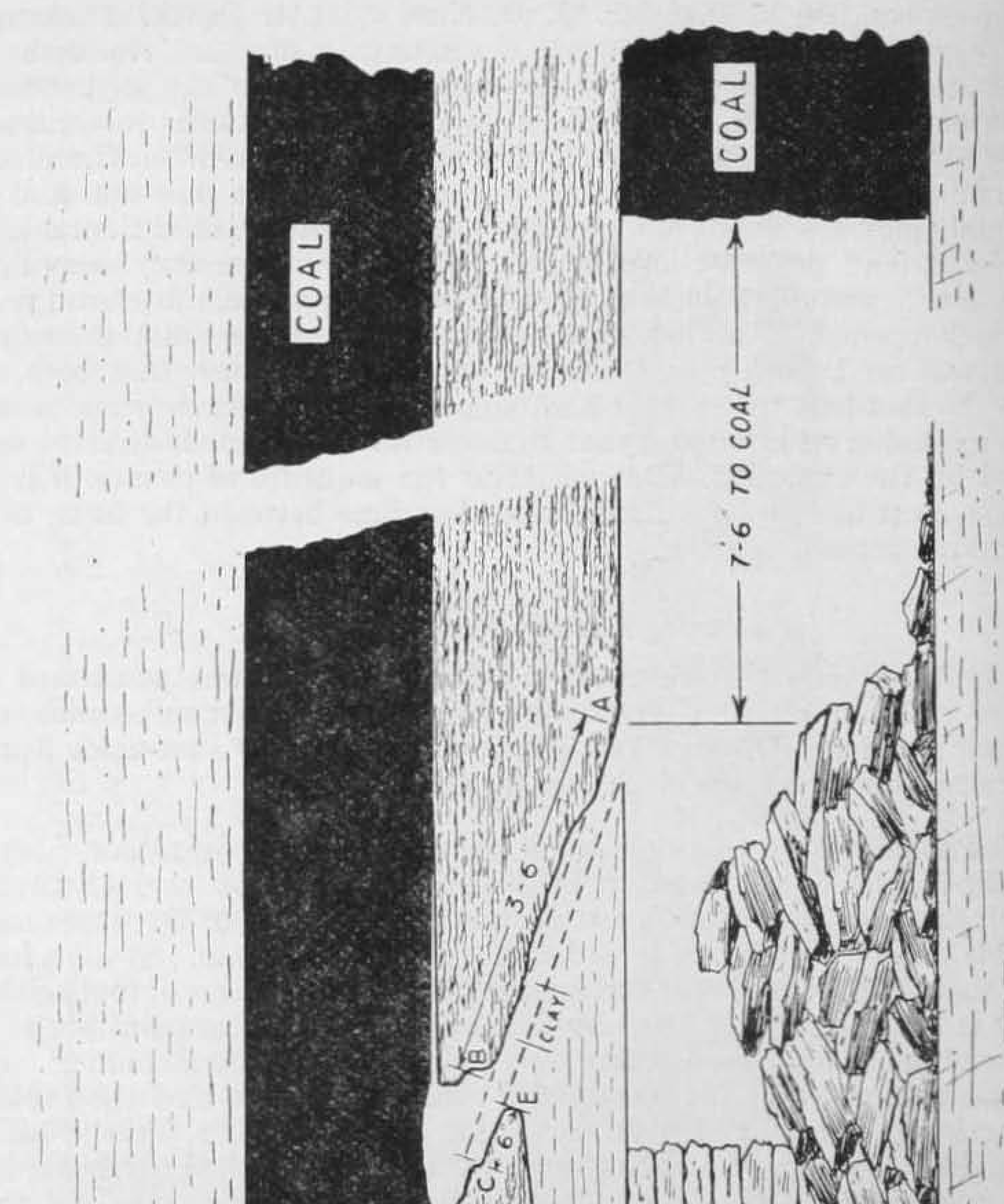


Fig. 2

firing of the shot had brought down the roof bed along the line of the hole between B and C and there was a 6-in. socket at the inner end. It is, therefore, highly probable that the explosive was not inserted to the end of the shot-hole but only as far as the point C, where there was a vertical roof fracture or cutter-break parallel with the face. As shown in the diagram, this break was closed laterally except for a small vertical pocket which crossed the hole, and it was found to extend upwards for about 3 in., where it was crossed by a horizontal parting, at least ½ in. wide, between the shale and coal beds. It is most unlikely that the vertical pocket was open to this extent before the shot was fired and it seems likely that it was partly filled with rock fragments which dropped away after the shot was fired. It is possible that the cross-section of the shot-hole was reduced at C by one of these fragments. Alternatively, there may have been a slight displacement across the vertical fracture at C, sufficient to disturb the continuity of the hole and thus prevent the charge from being pushed home.

47. In addition there was extensive bed separation between the shale and the coal. When obtaining gas samples in the vicinity of the shot-hole, it was found possible easily to push the metal tube—⅜ in. in diameter— through an opening at the back of the socket for a distance of at least 6 ft. The loudness of the noise made by the buried end of the tube during movement made it evident that this extended opening was horizontal and not far above the ripped surface of the roof bed. The experience of the investigators led them to conclude that this opening was present when the shot was fired. Measurements clearly showed that the back of the hole was drilled to within a very short distance—possibly to within ¼ in. at the nearest point—of the plane of bed separation, although at the time of the examination there was easy access through a thin layer of broken shale. It, therefore, remains a distinct possibility that this access existed at the moment of firing. The thrust of the drill could quite easily have broken the thin crust of shale for it must be remembered that the action of the shot itself did not produce any marked shattering of the socket.

48. Two other features peculiar to shot-hole No. 3 were also observed. On the ripped surface of the roof bed in the waste there were pronounced cleat planes. Along one, about 8 in. to the left of the shot-hole, there was an opening of about ¼ in. which extended to the bed separation cavity above the roof bed. There was another cleat plane 1½ in. to the right of the shot-hole and, although this was not nearly so open, it was nevertheless a plane of weakness which would facilitate a local displacement of the roof and reduce the strength of the shale at the end of the shot-hole. This cleat formed one end of the vertical pocket located at C. Moreover, on the right-hand side (looking towards the waste) of the ripped portion of the roof, there was a detached piece of the roof bed bounded by an open break DEF, Fig. 3, which extended laterally over the waste. The projected extension of this break towards the shot-hole would cross the hole almost tangentially at a point near the explosive charge if, as is likely, the hole was blocked or obstructed at the vertical fracture already described.

49. Three gas samples, S2, S3 and S4, were obtained near shot-hole No. 3. The position in which they were taken and their analyses are as follows :—

Position	*Methane per cent.*	*Carbon Dioxide per cent.*	*Oxygen per cent.*
S2. At top of vertical pocket	88·4	7·42	0·89
S3. Five feet into break developed towards right-hand waste	1·91	0·12	20·39
S4. Six feet in bed-separation cavity along direction of shot-hole	5·03	0·49	19·57

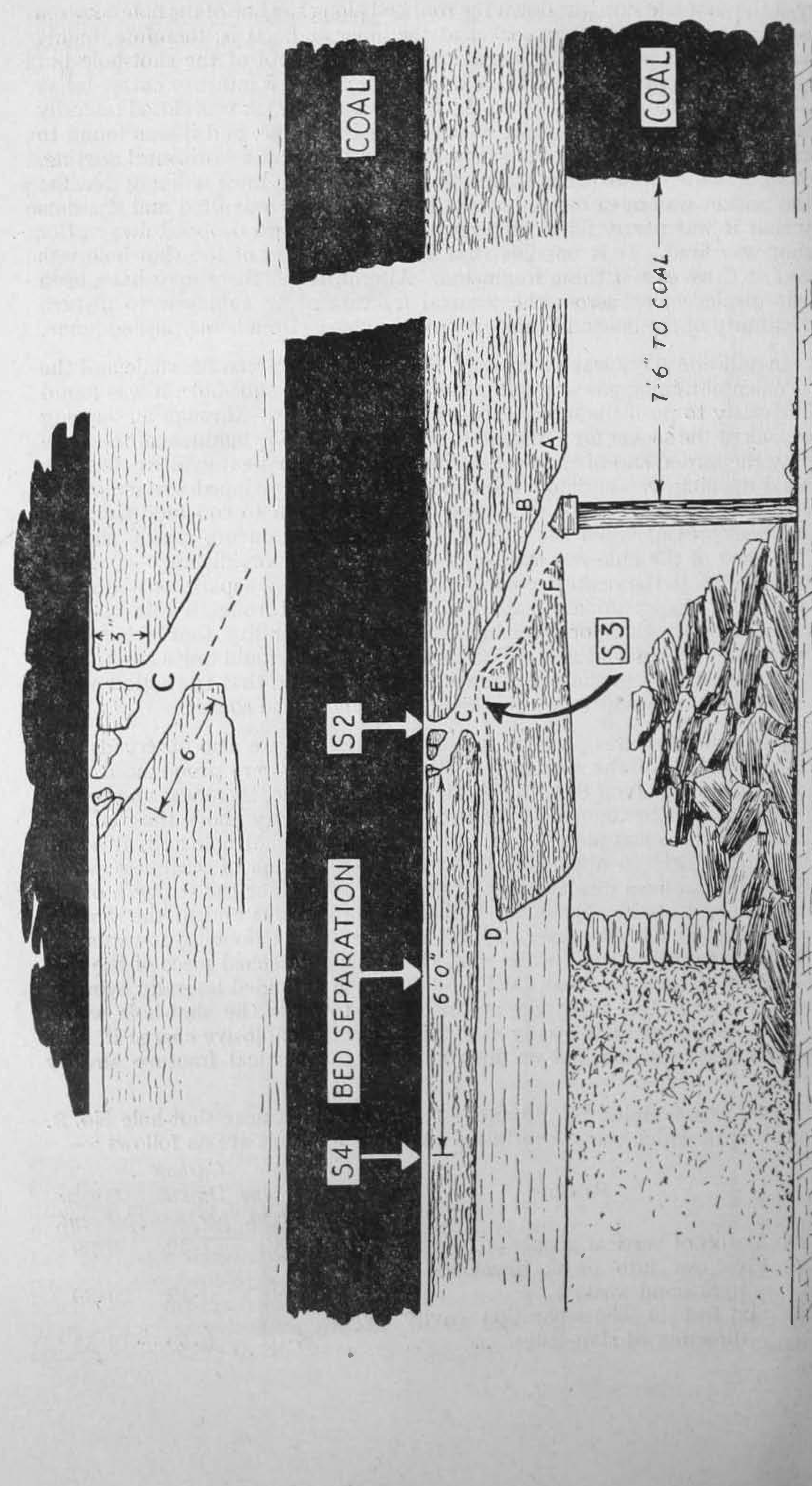


Fig. 3

The presence of the open cleat no doubt accounts for the lower percentage of methane in the sample taken some distance in the bed-separation cavity, but it is significant that the atmosphere here was inflammable and capable of self-propagation of flame at a slow speed.

50. From these considerations, I think there can be little doubt that the firing of shot No. 3 originated the explosion. Moreover, the circumstances were such that the firing of the shot was likely to result in an ignition of firedamp in the bed-separation cavity between the shale and the overlying coal, the flame of which would travel slowly and unobserved along narrow openings until it encountered a larger volume of firedamp and air in the waste, thus giving the delay indicated by the factual evidence, between the firing of the shot and the development of the main explosion.

V.—THE SPREAD OF THE EXPLOSION

(a) *Area Affected by the Flame*

51. With the exception of the Nos. 1 and 2 Rise Districts, Skelly's Heading and the No. 1 Dip Shortwall Face off No. 3 Trunk Road, the explosion traversed almost all other inbye working faces and roadways and continued outbye along the main return airway for a distance of 60 yards beyond the main air-crossing over No. 3 Trunk Road and along the main intake haulage road for a distance of about half-a-mile from its junction with No. 3 Trunk Road. In all, not less than 2,000 yards of roadway were traversed by the flame of the explosion.

(b) *Violence*

52. The explosion left a trail of death in its path and many heavy falls of ground. But apart from the badly wrecked main return air-crossing over No. 3 Trunk Road, there were few marked signs of extreme violence. Many empty tubs were left standing, signal wire supports were not bent, while roadway conveyors, although disturbed and distorted here and there, were not seriously damaged. This absence of signs of extreme violence suggests an explosion in a combustible mixture not far removed from the lower limit of inflammability. The numerous falls gave a deceptive appearance of violence. It is probable that these falls were largely due to the pressure of the explosion blast causing a slight lifting of the lower detached roof resting on the supports, thus easing the displacement of the supports.

(c) *Source of the Combustible Material*

53. As might be expected with so many interconnected open roadways, it was not easy always to determine the exact direction of the passage of flame in certain of the inbye roads; but this is of little moment. It is important, however, to determine the source and nature of the combustible matter which enabled the explosion to spread as far as it did. The initial explosion in the waste of No. 2 Dip Right Face was almost certainly of firedamp only, and was essentially one of firedamp so far as the major part of the No. 2 Dip area was concerned. Thereafter, the spread of the explosion outbye was no doubt greatly assisted by the firedamp released or pressed out from the waste towards the outer end of the mothergate, especially at a point where the explosion had dislodged a stopping and a small roadside pack (*see* Plan No. 3). This firedamp would readily assist the explosion in its passage in both directions along No. 2 Dip Trunk Road and also into the face of Allen's Drift where firedamp had previously been reported and which remained fouled with firedamp for some days afterwards. But the fact of the comparatively short spread of the flame along the main return airway does not suggest any extensive accumulation of firedamp in the district as a whole. Indeed, the weight of evidence suggested

that it was highly improbable that enough firedamp was available to propagate the flame of the explosion over the distance it was agreed the explosion extended. On the other hand, the great extension of the flame along the main intake suggests strongly that coal dust played no small part in propagating the explosion there.

54. Against the view that coal dust played an important part, the results of analyses of numerous dust samples taken after the explosion showed that a high standard of stone-dusting had been reached. Moreover, following the explosion, there did not seem to the ordinary observer much evidence of coking. Only on the New Conveyor Road leading from No. 2 Dip Trunk Road to the Back End Shortwall was coking at all obvious. It must not be assumed from this, however, that the part played by coal dust must necessarily have been small. On all roadways there was a thin dust deposit, such as might have been left by the passage of an explosion through a dust cloud containing an admixture of coal and stone dust. This thin deposit contained fine coke dust which was not obvious to the eye. The quantity of coked dust that is found depends on the quantity of coal dust exposed to flame, and if this dust is disseminated in a cloud, then most of the coal dust may be burned completely and the quantity of coke dust or coke deposit may be small.

55. After careful consideration of the evidence on this point, I am driven to the conclusion that it is highly improbable that enough firedamp was available to propagate the flame of the explosion along the 2,000 yards of roadway including, most strikingly, the half-mile along the main intake. Since the only other possible fuel was coal dust, and bearing in mind the high standard reached in stone-dusting, it is necessary to inquire in some detail for the possible source of the coal dust.

56. The most likely source was coal dust from the inbye conveyor roads. It is well known that in dry and dusty mines, coal dust collects rapidly when conveyors are in use and that this dust is notoriously difficult to keep constantly neutralized because it tends to accumulate insidiously, not only as a surface layer on the sides and roof, but also in quantity around loading and transfer points and under and along the whole length of the conveyor structures. In such places it is difficult of access for brush and shovel and the coal dust is, therefore, not removed by the ordinary cleaning-up process which normally takes place daily, or even several times a day, in the immediate vicinity of a loading point. This dust is, nevertheless, still readily accessible to a blast of air, such as would be created in the early stages of a firedamp explosion at or near the working face. Clearly, so long as any dust remained to be raised, such a blast could raise this dust continuously as it travelled outbye along the conveyor roads and might thus produce a long cloud of coal dust moving ahead of the flame but ready to be inflamed when the flame of the firedamp explosion caught it up. If, of course, the roadways had been recently treated with stone dust, then the blast would also raise some stone dust as well. But, even although some cleaning-up, and perhaps even stone-dusting, is done during a coal loading shift in and around conveyor loading points, it is almost certain that, in general, the top layer of dust throughout the length of any conveyor roadway toward the end of a loading shift is almost entirely composed of coal dust. This top layer of coal dust would not be so marked in an outbye main haulage road where the rate of deposition of coal dust is normally much less than that on a conveyor road.

57. It seems to me that something of that nature must have happened in this case. The explosion, as already pointed out, was not of a violent nature. I consider, therefore, that as the blast from the initial moderate firedamp explosion travelled along the inbye conveyor roads, it raised a continuous dust cloud,

composed mainly of coal dust from the recently deposited top layer and from beneath the conveyor structures ; that this dust cloud burned as the flame from the firedamp explosion caught up with it ; and that the blast also raised a cloud of dust from the main intake haulage road containing a much larger proportion of stone dust, but that as this dust was ahead of the coal dust blown from the inbye conveyor roadways, it did not contribute to the extinction of the explosion until the flame had travelled a long way outbye. I can see no other way of explaining why this explosion travelled for nearly half-a-mile outbye along an apparently well stone-dusted intake roadway.

58. If the explanation I have given is the right one then it stresses once again, and very forcibly, the danger of a thin top layer of coal dust on any roadway and, in particular, the need for unremitting and continuous attention to the neutralizing of the dust deposited in conveyor roadways, especially under the whole length of the conveyor structures and in and around loading and transfer points. It is more than thirty years ago since the Explosions in Mines Committee proved experimentally that coal dust lying on top of stone dust would propagate an explosion. Because of this knowledge, the original General Regulations of 1920 relating to Precautions Against Coal Dust required that the dust on the roof, floor and sides of roadways should consist of *an intimate mixture* of coal and stone dust containing not less than the prescribed percentage of incombustible matter. These Regulations were later amended in 1939 to require that such measures shall be taken as will ensure that on the floor, roof and sides, respectively, of every road or part of a road which is accessible, *the dust which can be raised into the air* shall contain not less than the prescribed percentage of incombustible matter. To maintain this dust—which may comprise only the thin top layer—in compliance at all times with the Regulations on any roadway, and especially on a conveyor roadway during a loading shift in a dry and dusty mine, is admittedly extremely difficult, if not quite impracticable. Clearly, the practice of scattering stone dust on such roadways by hand shovel in large quantity at infrequent intervals will not ensure compliance, because it does not neutralize the dangerous top-layer of coal dust which may be formed in a relatively short time and it does not ensure an intimate mixture. Much research has been done on this aspect of the dust problem in recent years by the Safety in Mines Research Board and other investigators. The danger presented by thin surface layers of coal dust is stressed in the 24th and 25th Annual Reports of the Board for the years 1945 and 1946, while details of the experimental work and suggestions for combating the danger are given in S.M.R.B. Paper No. 105 (published 1947). The problem was also referred to in a Paper,* read in 1937, of which I was a joint author. I am satisfied that, in relation to the propagation of an explosion, the full significance of the danger of a thin top layer of coal dust, such as may easily be deposited in some mines during a coal loading shift, and which may well form the bulk of *the dust which can be raised into the air*, is not yet sufficiently realized by the majority of mining men. It has been estimated that if the quantity of coal dust (of average inflammability) —sufficient to form a layer, a few 1/1,000ths of an inch thick on the roof, floor and sides of a roadway 50 sq. ft. in cross-section—were raised into suspension in that roadway, it would produce a cloud of sufficient density to propagate flame. I strongly urge, therefore, that in stone-dusting practice there should be strict adherence to the principle of " little and often ", i.e. the application of smaller quantities at more frequent intervals or, where practicable, the trial of some device which will ensure that sufficient (and no more) stone dust is disseminated at frequent intervals in the atmosphere of the roadways to mix and deposit along with the coal dust present, thus ensuring as near an approach as is

* Smellie, J. and Bryan, A. M.—" On the Efficiency of Incombustible Dust in the Prevention of Coal Dust Explosions "—Trans. Inst. Min. E.1937-38, XCIV.

practicable to an intimate mixture throughout. It occurs to me also, that if some practicable means could be devised for rendering and maintaining a roadway surface, and especially that part of the floor under conveyor structures, "dust intolerant", i.e. treated in such a way as would ensure that any coal dust deposited on it was rendered indispersable, the dust danger on conveyor roadways would be considerably lessened. It may be that the present research work on the consolidation of roadway dusts will lead to the development of a means to that end. Finally, I should like to press the point very strongly that if compliance with the dust regulations at all times in dry and dusty mines is to be reasonably assured, and the conditions in such mines are to be improved in respect of health and comfort, then all practicable steps must be taken in the first instance to prevent or reduce dust formation *at its source*, and to suppress by water infusion, sprays, wet-cutting, wet-drilling or other appropriate means, any dust that is inevitably made.

VI.—COMMENTS

SHOT-FIRING PRACTICE

(a) *On the Examination of the Shot-hole for Breaks*

59. Clause 6 (*d*) of the principal Explosives in Coal Mines Order requires that, before a hole is charged, the shot-firer shall examine it for breaks running along or across it. No scraper or other tool for detecting breaks was found in the vicinity of the No. 2 Dip Face and I can only conclude that, contrary to the Regulations, the shot-firer who charged and fired the fatal shot, and who lost his life in the explosion, had not examined the shot-hole for breaks. This was a grave omission. The condition of shot-hole No. 3, as examined several days *after* the explosion, has already been described and is illustrated in Fig. 3. Its condition then was such as would suggest that the presence of a break could readily have been detected had a proper tool been used for the purpose. Whether the condition of the shot-hole *before* the firing of the shot was such that a break could have been detected had the type of tool normally supplied at the colliery for detecting breaks been in fact used, is a matter for conjecture, but it does seem probable.

60. In mines where firedamp is a hazard, the examination of shot-holes for breaks seldom receives the close attention it merits, possibly in some measure due to the failure to use a properly designed and maintained break-detector. In view of the number of explosions of firedamp in recent years caused by shot-firing with permitted explosives in holes crossed by breaks, I am of the opinion that the use of a break-detector made to an approved specification and properly maintained should be made compulsory. Reference to this and other matters relevant to shot-firing practice is made later.

(b) *On the Examination for Inflammable Gas Before Shot-firing*

61. Clause 6 (*f*) (i) of the principal Explosives in Coal Mines Order requires that :—

> "No shot shall be fired, unless immediately before the shot is to be fired, the shot-firer has examined the place where the shot is to be fired and all contiguous accessible places within a radius of 20 yards from the place, and has found them clear of inflammable gas and in all respects safe for firing. If within the aforesaid radius of the place there is any cavity which may contain inflammable gas and cannot be so examined, or any break where an examination cannot be made for inflammable gas issuing from it (other than inaccessible cavities or breaks in the gob, goaf or waste) the shot shall not be fired."

62. In my Interim Report I pointed out that because of the words within the brackets in the above clause, it was permissible in law for a shot-firer to charge and fire a shot in close proximity to any inaccessible waste whether or not it contained or was likely to contain inflammable gas in such quantity as to be indicative of danger. I also stated that whilst I would not for one moment suggest that a shot-firer would fire a shot if he thought that shot would ignite inflammable gas, nevertheless I considered that the clause allowed too much latitude and that the statutory requirements of the firing of shots in all coal mines where inflammable gas was not unknown should be strengthened in such a way as to restrict the latitude allowed. The normal interpretation of " inaccessible " as used in Clause 6 (*f*) (i) is that the place cannot be examined by the shot-firer using his flame safety lamp. There is no doubt, however, that by means of, say, an aspirator attached to a thin tube or pipe, samples can be collected for examination so as to ascertain whether or not a so-called " inaccessible " waste in the immediate vicinity of a shot-hole does or does not normally contain inflammable gas in such quantity as to be indicative of danger. After all, inflammable gas in an " inaccessible " place in close proximity to a shot is no less dangerous than if it had been found in an accessible place near the shot.

(*c*) *On the Use of Sheathed Permitted Explosives*

63. Only sheathed permitted explosives were used in the shots fired on the No. 2 Dip Face on the shift in which the explosion occurred. There seems to be a view in some quarters—a view unwarranted by the facts—that the use of a permitted sheathed explosive surmounts the potential danger of ignition of inflammable gas by shot-firing. It has been known, however, for many years, that it is potentially dangerous to fire a shot in a hole which passes through a break connected with a bed-separation cavity or a waste in a gassy mine, even when permitted and sheathed explosives are used and where the general ventilation of the mine is considered good in terms of Section 29 of the Act. Nevertheless, the exact conditions necessary for ignitions in these circumstances cannot yet be defined. With a view to their determination, a series of experiments was conducted several years ago at the Laboratories of the Safety in Mines Research Board, but they proved inconclusive because of the limitations of the " Break Gallery " in which the experiments were conducted. Plans have been prepared for the provision of a new " Break Gallery " which will permit a greater range of experimental conditions. In view of the number of ignitions and explosions initiated by the firing of shots in holes associated with breaks and open partings, it is essential in the interests of safety that research on this problem should be undertaken without further delay. I recommend, therefore, that immediate steps be taken to expedite this investigation. In this connexion, bearing in mind the practical difficulty of ensuring at all times that a shot-hole is not associated with breaks or partings, and other matters relevant to this explosion, I cannot do better than quote, in full, Safety Circular No. 137, issued on the 24th October, 1945, by my predecessor, Sir John R. Felton. It was addressed to the Owners and Managers of all Mines under the Coal Mines Act, 1911, and the Secretaries of National and Local Associations of Owners, Officials and Workmen. It reads :—

> " It is clear from the records of ignitions of firedamp caused by shot-firing with permitted explosives that the most dangerous condition for firing is when the shot-hole crosses, or ends in or very near to, a break or parting.
>
> As regards breaks *crossing* the shot-hole the work of the Safety in Mines Research Board carried out over many years has all gone to show that the danger of an ignition of firedamp is substantially reduced if a sheathed explosive is used. The ends of the cartridges are not sheathed and it seemed

desirable, therefore, to study experimentally the possibility of providing further protection against an undetected break *at the back* of the shot-hole by a plug of clay inserted before the hole is charged. That has been done and a full account of the experiments has recently been published in the technical press.

These experiments having shown that an additional means of safety is thus provided, I commend for general adoption, wherever permitted explosives are used, the very simple practice of pushing a plug of stemming to the back of the hole before it is charged.

I must, however, emphasize that neither the sheathing of the explosive, nor a plug at the back of a hole, nor anything else yet known, will make it safe to fire a hole in which any break has been found, and that the prohibition against this in Clause 6 (*d*) of the Explosives in Coal Mines Order, 1934, remains in force.

The dangers need to be more fully appreciated and shot-firers should be fully instructed as to the risks involved. They should be supplied with an effective break detector and be trained in its use. The best form of appliance is one designed for the purpose, that is, with a sharply defined 'V' pointed projection at its head, and which does not bend readily in use."

(*d*) *On the Storage, Use and Handling of Explosives, and Shot-Firing Practice in General*

64. It was clear from the evidence of various witnesses in regard to such matters as (i) lack of agreement between the records of explosives and detonators issued from and returned to the surface store and the records of explosives and detonators issued to and used by shot-firers and deputies underground; (ii) the finding of cartridges of explosives underground in places other than in secure cases or canisters; (iii) the finding of detonators in places other than suitable and securely locked cases or boxes; (iv) the finding of sheathing removed from cartridges; (v) the siting of shot-holes; (vi) the record of the number of shots fired by a deputy with statutory duties to perform; (vii) the apparent failure of a shot-firer to comply with certain requirements of the Explosives in Coal Mines Order before firing a shot; and (viii) the high quantity of explosive used per ton of coal got; that the whole business of storage, use and handling of explosives and shot-firing practice in general was not given enough care and attention.

65. It was disclosed, for example, that on the day-shift preceding the shift on which the explosion occurred, the No. 2 Dip Face deputy had fired forty-two shots in addition to performing his statutory duties. Plainly his statutory duties, or his shot-firing duties, or perhaps both, could only have been carried out in a very perfunctory manner. It was also disclosed that the position and number of shot-holes required were left too much to the discretion of the hole-borer. Although a shot-firer need not charge every shot-hole, and certainly ought not to charge and fire a shot in a hole that is not properly placed, nevertheless it is a sore temptation to him to make use of all shot-holes that are drilled.

66. This whole business of the use and handling of explosives, and all operations connected therewith, is of vital importance to the safe working of a colliery. It is essential for the management, therefore, not only to see that an efficient system governing all phases is laid down, but also that the necessary supervision is given to see that it is properly carried out. As so often happens, what is the business of everybody becomes in the end the business of nobody. I suggest, therefore, that at all collieries where explosives are used, a thorough investigation should be made into this matter with the object of devising the most efficient system appropriate to the circumstances; and that, thereafter,

a superior and responsible official of the mine should be given the direct responsibility of seeing that the approved system is efficiently applied and operated in practice on all three shifts. In my Interim Report I also recommended that it should be made a statutory requirement that the maximum number of shots which it is permissible for shot-firers and deputies, respectively, to fire, should be fixed for each district of the mine after a trial made under working conditions, both in respect of the number of shots per statutory shift and per hour during the shift, the trials to have regard, in the case of a deputy, to his primary responsibility to carry out his statutory duties and, in the case of both shot-firers and deputies, to any additional duties which may be assigned to them, and any assistance given to them.

(*e*) *On the Practice of Firing Roof Shots on Longwall Faces to Obtain Packing Material*

67. As already explained, this explosion originated with the firing of a shot in a hole drilled at an angle into the roof on a longwall face and directed towards the waste behind and immediately contiguous to the face. The purpose of this shot, and of several others fired that night on the No. 2 Dip Face, was to obtain packing material to extend the strip packs in the waste. Such shots are variously known as "cuckoos", "uppers" or "upper-cuts". The practice of firing them is (or was) common in several collieries in different parts of the country. Since, by definition, the practice applies only to shots fired at or near the edges of wastes on longwall faces, it is a practice fraught with grave risk and danger in many mines. It will not be denied that in a mine where firedamp is not unknown, a waste behind a longwall face is a place where inflammable gas is most likely to be found and is, morever, a place which cannot be examined for the presence of inflammable gas in the normal way by a deputy or shot-firer using his flame safety lamp. Further, the roof at or near the edge of a waste is just the place where breaks and bed-separation cavities are extremely prevalent and most liable to occur. This combination of dangerous factors, inflammable gas in conjunction with breaks or cavities, clearly indicates that the practice of firing "cuckoo" shots should be avoided like the plague.

68. In evidence, the Manager not only stated that he was unaware that "cuckoo" shots were being fired but that he had given instructions that such shots were not to be fired. Either these instructions had not been clearly given or understood, or the supervision was insufficient to see that his instructions were properly carried out. The fact remains that "cuckoo" shots were fired and that the firing of one of them originated the explosion. Nevertheless, the Manager did not regard the practice as a dangerous one, provided, as he said, "it was properly carried out". As I have already made plain, I regard the practice as one which should be prohibited in mines where firedamp is a hazard. In my Interim Report I suggested that, until the present statutory requirements in relation to shot-firing had been suitably amended or extended in all coal mines where there was firing of "cuckoo" shots in close proximity to wastes containing or likely to contain inflammable gas in such quantities as to be indicative of danger, the management should consider immediately the taking of one or other or all of the following steps :—

(*a*) Prohibit the practice of firing "cuckoo" shots charged with explosives ;

(*b*) Keep the wastes as clear as possible from dangerous accumulations of firedamp ; and

(*c*) Strengthen the system of support and roof control not only to prevent as far as practicable the formation of roof breaks and bed-separation cavities, but also to encourage the roof in the wastes to break down regularly as the temporary supports in the wastes are withdrawn.

69. I am satisfied that much can be done by the application of efficient roof control measures to eliminate entirely the necessity for firing "cuckoo" shots. After all, there are whole areas in the country where this practice is unnecessary even where roof beds are equally as hard as those in areas where the practice exists. Strong straight rows of supports applied along the edges of wastes and well-built packs of good quality, suitably dimensioned and spaced, would in most, if not all, cases concentrate force sufficient to cause the roof to break down in the wastes. Moreover, effective roof control measures may do much to control and even reduce the rate of emission of firedamp at or near working faces and also prevent the formation of open breaks which often contain inflammable gas. Such breaks often communicate with and provide paths for draining off accumulations of firedamp in bed-separation cavities and wastes, or for the leakage of the air necessary to produce an inflammable mixture in such places. Further, with effective roof control there would be less tendency for the formation of bed-separation cavities, for the sudden issue or migration of accumulations of gas from the waste into the roadways and working faces, due to excessive weighting and heavy falls in wastes, and for uncontrolled leakage of air to places where such leakage may be dangerous. Indeed, quite apart from its probable beneficial effect on production, I can think of no other matter likely to pay greater dividends in relation to safety in mines generally than proper attention to roof control.

GENERAL

(*f*) *On the Adequacy of the Ventilation*

70. Since adequate ventilation is the first and by far the most important defence against explosions of inflammable gas, it was not surprising that many questions at the Inquiry were directed towards establishing whether or not the ventilation was adequate at the time of the explosion. Although it was clearly established, as will be evident from the air measurements recorded on Plan No. 1, that there was a considerable drop in the quantity of air reaching the working faces in the Six-Quarters Seam as compared with the quantity passing in both the main intake and return airways near the shafts, nevertheless there was no evidence to support any view that the quantity reaching the working faces was insufficient to ensure adequate ventilation under normal conditions. This conclusion was supported by the few instances where small percentages of inflammable gas were detected and recorded by the deputies and also by the results of analyses of air samples. It was also clear, however, that the ventilation was capable of improvement by a further reduction of leakage, by some re-arrangement of the inbye air-circuits and by enlargement of certain airways, and, indeed, work towards effecting improvements in all of these was in actual progress at the time.

71. The trouble in this explosion was that the inflammable gas had collected in a part of the mine, namely the goaf or waste behind the No. 2 Dip Face, and bed-separation cavities associated with that waste, where the gas was out of direct contact with the general ventilation. Consequently, any increase in the quantity of air passing along the No. 2 Dip Face would not have materially changed the condition or lessened the potential danger from this accumulation of inflammable gas. A reservoir of inflammable gas anywhere in a mine is always a potential source of danger ; but it becomes a lively hazard if it is near, or may react upon, a working place, or near any possible source of ignition. And in these circumstances it is clear that the more the gas accumulation is out of the direct path or sweep of the general air current, the more difficult does it become to take effective steps to guard against the danger from it by

means of direct ventilation. In all coal mines where inflammable gas is not unknown it is therefore incumbent upon all responsible for the management to see that, quite apart from any other steps they may take to overcome the potential danger, all ignition hazards are eliminated in proximity to wastes unless it is known that the wastes are free from dangerous accumulations of inflammable gas.

(g) *On the High Death Roll*

72. It will be seen from Appendix III, prepared by Dr. A. Roberts, H.M. Mines Medical Officer for the Northern Region, that forty-five of the victims whose bodies were found on the inbye-side of the air-crossing on No. 3 Trunk Road, died of carbon monoxide poisoning. None of these bodies showed any sign of burning and only one showed any mark of physical violence—a fractured skull, probably sustained after the occurrence of the explosion. These victims had all been employed in that part of the workings comprising Skelly's Heading, No. 2 Rise District and No. 1 Dip off No. 3 Trunk Road. It is clear that these men had not been in an area traversed by flame or subject to serious violence, that they must have survived the actual explosion, that they had travelled some distance after the event before they were subsequently overcome by the deadly afterdamp of the explosion, and that they had a more or less equal chance of survival to the three survivors, Birkett, Hinde and Weighman, who were employed in the same area of the mine.

73. While it was unfortunate that none of these forty-five men went back with the three survivors, nevertheless it is probable that if these men, some of whom must certainly have known that an explosion had occurred and who had some opportunity to determine their course of action, had been provided with a ready means of protection against carbon monoxide, the death roll might well have been reduced. It is seldom that the oxygen content of the afterdamp of an explosion is so low as to be unable to support life. Largely because of stone-dusting and more effective ventilation systems, it is a feature of most explosions in recent years that they are less violent and are confined to smaller areas of the pit than were the explosions of earlier years, but that, due to the higher concentration of men demanded by modern mining, the death roll per unit of area covered is larger than formerly. Nevertheless, a high proportion of the deaths is still due to carbon monoxide poisoning. Following the considerable research during recent war years into means of protection against poisonous gases, it may be well worth while reconsidering the design of self-rescue respirators, with a view to providing miners with a more suitable form of protection against an atmosphere containing sufficient oxygen to support life but contaminated by carbon monoxide—such as often occurs in the after-damp of an explosion—and thus enabling the wearer to reach a place of safety.

(h) *On the Operation and Organisation of the Trained Rescue Brigades*

74. As might be expected in such large-scale operations as took place on this occasion, where things had to be done and arranged with the least possible delay, it was not surprising that a careful review of all that happened revealed a few weaknesses in the organisation. My object in directing attention to this matter is not for the purpose of suggesting that blame attached to anyone—for all gave of their very best and their conduct was most praiseworthy—but with a view to effecting improvements in the organisation in future. Two weaknesses were the failure to observe the need at an earlier stage in the operations (i) for additional Proto Apparatus and instructors trained in its use, with the result that the staff of the local Brigham Rescue Station was overworked and the fresh air base was not at all times under the supervision of a man of instructor

status ; and (ii) for a rest for some of the members of the teams whose efficiency was beginning to be affected by overwork. Further, the accommodation available for the large number of rescue men and for the handling of the necessary equipment was inadequate. One small room was provided for the " Proto " and one for the " Liquid Air " apparatus. This was certainly a fair share of the total available accommodation at the colliery for all purposes, but the desirability of providing temporary erections, such as tents or prefabricated structures, is well worthy of consideration at such times.

75. Another weakness was the use of two different types of self-contained breathing apparatus. It so happens that the Brigham Rescue Station, in common with the majority of Central Rescue Stations in this country, is equipped with " Proto " apparatus using compressed oxygen, whereas the Durham and Northumberland Stations, which supplied many teams, are equipped with " Liquid Air " apparatus. The use of these two different types of apparatus was undoubtedly a complication. From the points of view of supervision, standardization, efficiency and interchangeability, it is eminently desirable that all Central Rescue Stations in a Division should be equipped with the same type of apparatus. Experience gained in this disaster also shows the need for the management at every colliery to be provided beforehand with a detailed plan of operations for dealing with any serious emergency that may arise at the colliery.

(*i*) *On the Need to take Special Measures to Safeguard Against Explosions and Fires in the Whitehaven Group of Collieries*

76. In the light of this explosion and of previous disasters in the collieries immediately in and around Whitehaven, it is clear that this part of the Cumberland Coalfield presents abnormal difficulties and special problems, and that additional precautions are called for if the dangers of underground explosions and fires are to be surmounted.

77. There are several adverse factors which affect the safe working of collieries in this area where coal has been worked for at least two centuries. The collieries are relatively gassy, dry and dusty ; there are extensive areas of goaf or waste in many of the seams ; there are several areas sealed off because of previous underground fires ; the pits are very " one-sided " because most of the districts are working under-sea coal ; many of the working districts are a long distance inbye from the shafts ; there are still large areas of distant under-sea coal to be worked ; and there is a history of underground fires due to the liability of some of the seams to spontaneous combustion.

78. These adverse factors call for (i) a high standard of ventilation ; (ii) adequate dust prevention and suppression measures ; (iii) the elimination as far as practicable of all possible sources of ignition ; (iv) continuous and close supervision by responsible officials of all operations on all shifts ; and (v) the maintenance of a high standard of discipline. Whilst the need for all of these is well appreciated by the managements, I am satisfied that there is still room for improvement in respect of each of them. History shows that the standards which must be maintained in these matters in the Whitehaven pits need to be well above the average. In regard to item (iv), for some months prior to the explosion there was no under-manager at William Pit, due to the difficulty of securing a suitable man for the post. But in respect of each Whitehaven pit, not only should there be an under-manager, there should also be a responsible official in charge of the mine on shifts when neither the manager nor the under-manager is on duty, who should exercise the responsibilities of, and be not less qualified than, an under-manager.

79. There is no doubt whatever that the adverse factors just enumerated also make the ventilation problem at the Whitehaven pits especially difficult. They call for the provision of sufficient, well-maintained airways of ample dimensions ; the elimination of all unnecessary resistance to the passage of air through the airways ; the judicious splitting of the air current and the careful balancing of air splits ; comfortable air velocities and reasonable pressures ; close and constant watch on all development work to ensure not only that efficient and adequate ventilation is provided in the development work, but also to see that the balance between the various splits is properly maintained ; the elimination of all unnecessary leakage and control of any leakages considered necessary ; a very high standard of practice in relation to the construction and maintenance of doors, sheets, stoppings, etc., because of the high ventilation pressure necessitated by long airways ; and last, but not least, the provision of efficient means to ensure the circulation of an adequate volume of air throughout the workings. Accurate information on most of these factors requires regular ventilation surveys for quality, quantity and pressure. Here again, although the necessity for all of these things is also appreciated and a high standard is maintained in respect of some of these items, nevertheless I feel sure there is room for further improvement in regard to most of them.

80. In my view the whole problem is so important, complex and difficult that it cannot properly be left solely to the mining engineers and managers responsible for day to day coal production. I am of the opinion that it requires the full-time services of a mining engineer, highly qualified in the science and practice of mine ventilation, who has also an intimate knowledge of explosion and fire hazards, particularly in the Whitehaven area. I suggest this specialist engineer should be employed not only for the major planning and continuous development of the system of ventilation but also that he should have a direct responsibility along with the management at each colliery for seeing that the plans are properly carried out, and that any tendency to deviate from them is immediately checked and corrected. It should also be part of the responsibility of the specialist engineer, as well as of the management, to see that all practicable steps are taken to eliminate or safeguard against all possible explosion or fire risks. And he should be allotted sufficient assistance to enable him to carry out his duties efficiently. A prime essential to the successful working of the under-sea coalfield of Cumberland, and a major problem to be solved if success is to be assured, is the provision and maintenance of adequate ventilation, for upon this depend the amount of output, the type of machinery and the system of mechanisation that can be adopted and, above all, the health and safety of the persons employed. No doubt the lessons to be learned from past experience at Whitehaven have been carefully noted by those now engaged in the planning of new ventures to work the remaining under-sea coal in this coalfield.

VII.—SUMMARY OF CONCLUSIONS

81. Summarising the results of the Inquiry, I consider it established that :—

(1) The explosion originated with the firing of a charge of sheathed permitted explosive in a shot-hole drilled in the roof and directed towards the waste behind and immediately contiguous to the No. 2 Dip longwall machine-cut conveyor face in the Six Quarters Seam.

(2) Before the shot-hole was charged it had not been examined for breaks running along or across, contrary to the requirements of Clause 6 (*d*) of Part II of the principal Explosives in Coal Mines Order.

(3) The shot-hole passed through a roof break or breaks and the inner end of the hole either made contact with, or was in very close proximity to, a bed-separation cavity containing inflammable gas which was continuous with an accumulation of explosive gas in the contiguous waste or goaf.

(4) The firing of the shot ignited the gas in the bed-separation cavity.

(5) The gas in the cavity burned for a short interval of time and the flame travelled along the cavity until it reached the explosive mixture in the waste, causing a firedamp explosion.

(6) The flame of the explosion traversed several working faces and nearly 2,000 yards of roadway, including several inbye conveyor roads, about 60 yards of the main return airway and nearly half a mile of the main intake haulage road.

(7) The explosion was marked by few signs of extreme violence.

(8) The initial explosion was almost certainly one of firedamp only. The blast from this initial explosion raised a dust cloud ahead of it and as the explosion travelled on its path the nature of the combustible mixture gradually changed from firedamp-and-air through firedamp-coal-dust-and-air to practically coal-dust-and-air alone, before the flame was finally extinguished by excess of stone dust in the dust cloud.

(9) The excess of coal-dust in the dust cloud was mainly derived from under the roadway conveyor structures and from the recently deposited top layer along the whole length of the inbye conveyor roads, while the stone dust was mainly derived from the main intake haulage road. This stone dust was projected ahead of the coal dust blown from the inbye conveyor roads and did not contribute to the extinction of the explosion until the flame had travelled nearly half a mile outbye along the haulage road.

VIII.—RECOMMENDATIONS

82. The Inquiry has disclosed that certain improvements or changes are desirable, and I make the following recommendations :—

(*a*) *Shot-Firing*

(1) In all coal mines where inflammable gas is not unknown, the provision of Clause 6 (*f*) (i) of the principal Explosives in Coal Mines Order, which in effect permits the firing of shots in close proximity to inaccessible cavities or breaks in the gob, goaf or waste, should be strengthened in such manner as to restrict the latitude now allowed.

(2) The firing of that type of shot variously known as " cuckoo ", " upper " or " upper-cut ", *i.e.*, a shot fired in the roof near the edge of a waste behind a longwall face, should be prohibited in mines where permitted explosives are required because of possible danger from inflammable gas, except with the written authority of the Agent and Manager ; and that before such authority is granted, the Agent and Manager must satisfy themselves, firstly, that it is not reasonable or practicable to break the roof down otherwise than by shot-firing and, secondly, that the air in the waste does not normally contain more than one per cent. of inflammable gas.

(3) The use of a break detector made to an approved specification, and properly maintained, should be made compulsory.

(4) The maximum number of shots which it is permissible for shot-firers and deputies, respectively, to fire, should be fixed for each district of the mine after a trial made under working conditions, both in respect of the number of shots per statutory shift and per hour during the shift, the trials to have regard, in the case of a deputy, to his primary responsibility to carry out his statutory duties and, in the case of both shot-firers and deputies, to any other duties which may be assigned to them or to any assistance given to them.

(5) A thorough investigation should be made by the management of all collieries where explosives are used into the whole business of storage, records, use and handling of explosives and shot-firing practice in general, including hole-boring, with a view to devising the most efficient system appropriate to the circumstances, and thereafter a superior official of the mine should be given the responsibility of seeing that the approved system is efficiently applied and operated in practice.

(6) Immediate steps should be taken to expedite research work with a view to determining (*a*) the conditions necessary for ignition when a shot is fired in a hole connecting with a break or parting containing inflammable gas, and (*b*) the necessary safeguards against such ignition ; and that, in the meantime, wherever permitted explosives are used, the very simple practice of pushing a plug of stemming to the back of the hole before it is charged should be generally adopted.

(*b*) *Precautions Against Coal Dust*

(7) In regard to the use of inert dust for neutralizing coal dust on roadways, the principle of "little and often", *i.e.*, the application of small quantities at frequent intervals, should be more generally adopted and should be standard practice for all roadways in which coal conveyors are used.

(8) All practicable steps should be taken to prevent or reduce dust formation at its source and thereafter to suppress, by water infusion, sprays, wet-cutting, wet-drilling or other appropriate means, the inflammable dust that is inevitably made.

(*c*) *Rescue and Recovery Work*

(9) Steps should be taken to standardize the type of self-contained breathing apparatus provided for the use of Rescue Brigades within each geographical Division of the National Coal Board.

(10) The management at each mine should have in readiness a detailed plan which can be operated promptly and effectively in the event of a serious emergency arising at the mine.

(11) In view of the number of lives lost due to carbon monoxide poisoning following recent mine explosions and fires, the question of developing a simple, suitable and easily portable mask for the protection of miners against carbon monoxide—a subject which has received some consideration in past years—is well worthy of reconsideration.

(12) The use of trained dogs to assist in the recovery of missing bodies of victims of mine disasters is well worthy of further consideration and trial.

(*d*) *Appointment of Specialist Mining Engineer and Supervision by Responsible Officials*

(13) A full-time mining engineer, with an intimate knowledge of mine explosion and fire hazards and highly qualified in the science and practice of mine ventilation, should be appointed for the collieries in the Whitehaven district.

His duties should comprise the planning and direct supervision of the ventilation system ; the development and application of measures to eliminate or safeguard against all explosion and fire risks ; and he should have a definite responsibility for these matters along with the managements of the collieries concerned.

(14) In each of the Whitehaven collieries, in addition to the Manager and Under-manager, there should be a responsible official in charge of the mine on shifts when neither the Manager nor the Under-manager is on duty, who should be not less qualified than an under-manager.

IX.—CONCLUDING REMARKS

(a) *Action Taken and Pending on the above Recommendations*

83. I am pleased to report that action has already been taken to implement certain of the above Recommendations, some of which were included in my Interim Report presented on 15th October, 1947. The Explosives in Coal Mines Order, 1948, which was made on 4th February and came into operation on the 16th February, covers Recommendations (1), (2) and (4) above. In addition, you were pleased to set up a Committee under my Chairmanship and representative of all sides of the Industry, to inquire into the precautions necessary to secure safety in the use of explosives in coal mines. This Committee has already begun its labours and will include, among other things, Recommendations (3) and (5) within the scope of its inquiry. Moreover, as a result of experience in recent mining disasters and following upon Recommendation (6) in my Report last year upon the Explosion and Fire at Burngrange Nos. 1 and 2 (Oil Shale) Mine, Midlothian, the National Coal Board has already set up a Committee, with representatives of the Ministry of Fuel and Power as Assessors, to report upon the efficient organization of a Mines Rescue Service in each Division. This Committee will include within its scope all the above recommendations dealing with Rescue and Recovery Work. Recommendation (11) has also been referred to the representative Rescue Advisory Committee of the Ministry of Fuel and Power.

(b) *Acknowledgments*

84. Finally, I desire to pay tribute to the excellent work done by all who took part in the rescue and recovery work and to those who attended to the needs of all rescue workers when they came out of the pit at all times during several days and nights. I should also like to express my sincere thanks for the help and co-operation given to me by the representatives of all parties to the Inquiry ; by Mr. H. Offord, Clerk of Court ; by Mr. J. G. Helps, Area General Manager ; by Mr. R. W. Gallantry of the National Coal Board and his staff in the Surveyor's Office for the excellent and numerous plans provided ; by Mr. R. J. Edwards, H.M. Divisional Inspector of Mines and his staff ; and by Dr. H. F. Coward and members of staff of the Ministry's Safety in Mines Research and Testing Branch.

I have the honour to be, Sir,

Your obedient Servant,

A. M. BRYAN.

APPENDIX I

WILLIAM PIT EXPLOSION

Killed

Body No.	*Christian Name*	*Surname*	*Age years*	*Occupation*
1	Thomas Arthur ..	.. Nelson	36	Brusher.
2	Edward	.. Glaister	48	Brusher.
3	Thomas	.. Allan	33	Stoneworker.
4	James William ..	.. Lambert	36	Brusher.
5	John Nelson ..	.. Garner	37	Brusher.
6	Richard	.. Cartmell	25	Panpuller.
7	James	.. Clifford	26	Panpuller.
8	Matthew	.. Wilson	45	Deputy.
9	John	.. Anderson	50	Panpuller.
10	Richard Edward ..	.. Grearson	46	Brusher.
11	Joseph Wilson ..	.. Hewer	40	Deputy.
12	Joseph	.. Brannon	45	Coal-cutter
13	William	.. Martin	32	Coal-cutter.
14	Vincent	.. McSherry	37	Brusher.
15	Thomas	.. Fox	24	Panpuller.
16	William Foulder ..	.. Grearson	38	Brusher.
17	John	.. Milburn	40	Brusher.
18	William Harker ..	.. Lee	27	Brusher.
19	Jacob Edward ..	.. Bridges	37	Coal-cutter.
20	George	.. Hutchinson ..	44	Face Worker.
21	William	.. Nicholson ..	33	Deputy.
22	John	.. Quirk	38	Brusher.
23	William Telford ..	.. McMullen	22	Face Worker.
24	Henry	.. Shilton	44	Brusher
25	James	.. Rigg	28	Brusher.
26	William Henry ..	.. Crofts	42	Brusher.
27	Thomas	.. Turner	46	Shift-hand.
28	Isaac	.. McAllister	55	Shift-hand.
29	John Richard ..	.. Mowat	26	Brusher.
30	George Henry ..	.. Wilson	29	Shift-hand.
31	George	.. Porthouse	58	Brusher.
32	Thomas	.. Richardson ..	42	Brusher.
33	Ronald William ..	.. Hewer	38	Brusher.
34	William	.. Clark	46	Brusher.
35	William	.. Williamson ..	27	Brusher.
36	James	.. Murray	35	Panpuller.
37	Edward Reuben ..	.. Ray	32	Shift-hand.
38	Henry	.. Gibson	36	Brusher.
39	William	.. Fisher	38	Brusher.
40	James Richardson	.. Barwise	49	Brusher.
41	Walter	.. Wylie	36	Brusher.
42	James	.. Campbell	40	Machine-man
43	Albert Edward ..	.. Saulters	40	Panpuller.
44	James	.. Leeson	48	Brusher.
45	Joseph Gerald ..	.. Diamond	33	Brusher.
46	William Lewis ..	.. Pickering	24	Panpuller.
47	Thomas James ..	.. Shackley	40	Panpuller.
48	Thomas Gladstone	.. Dixon	55	Brusher.
49	Adam	.. Raby	25	Brusher.
50	Mark Jackson ..	.. Shaw	45	Pipe fitter
51	Ronald	.. Hughes	20	Shift-hand.
52	John Henry ..	.. Maddison	22	Face Worker.
53	Samuel	.. Devlin	27	Shift-hand.
54	John Douglas ..	.. Allen	59	Contractor.
55	Joseph	.. Wilson	37	Brusher.
56	Ralph	.. Walker	34	Shift-hand.
57	Thomas	.. Lancaster	27	Brusher.
58	Francis	.. Murdock	38	Shift-hand.
59	Hartley	.. Byers	35	Brusher.
60	Albert	.. Tweddle	41	Brusher.

APPENDIX I—(*contd.*)

Body No.	*Christian Name*	*Surname*	*Age years*	*Occupation*
61	Henry Trohear	Allan	39	Brusher.
62	William	Johnston	27	Trainee.
63	James	Moore	62	Shift-hand.
64	George	Johnstone	41	Brusher.
100	Thomas	Pilkington	27	Brusher.
101	Richard	Atkinson	28	Pipe Fitter
102	Henry	Barker	34	Face Worker.
103	Harold John	Carr	21	Shift-hand
104	William	Pilkington	66	Brusher.
105	John	Pilkington	32	Brusher.
106	Dennis	Lyons	31	Panpuller.
107	William Ronald	Musson	22	Brusher.
108	James Murray	Bowes	34	Coal Cutter.
109	John Joseph	Renwick	39	Coal Cutter
110	John Edward	Moore	37	Panpuller.
111	John	Robbs	56	Brusher.
112	James	Gibbons	47	Brusher.
113	Robert	Conkey	43	Brusher.
114	Thomas Barnes	Smith	62	Brusher.
115	Thomas Thompson	Smith	36	Brusher.
116	Herbert	Calvin	40	Brusher.
117	Harold	Smith	41	Brusher.
118	Lawrence Hatfield Patrick	Murtagh	41	Deputy.
119	Thomas	Brannon	57	Chock Drawer.
120	James	Atkinson	45	Brusher.
121	Andrew	Agnew	36	Brusher.
122	Edward	McAllister	24	Brusher.
123	William	Pilkington	51	Face Worker.
124	Richard	Musson	36	Trainee.
125	Thomas	Woodend	64	Shift-hand
126	Leonard	Seward	36	Brusher.
127	Joseph	Norman	41	Face Worker
128	James	McMullen	27	Deputy.
129	John Allen	Paragreen	30	Engine Fitter
130	Sydney	O'Fee	34	Face Worker.
131	William Arnott	Walby	46	Shift-hand.
132	Patrick	Murtagh	28	Panpuller.
133	Wilfred	Farrer	34	Panpuller.
S1	Joseph	Fox	37	Airways repairer.
S2	Joseph Banks	Marshall	47	Shift-hand.
S3	William	Murray	39	Panpuller.
S4	Robert Mulholland	Glosson	39	Panpuller.
S5	John Henry	Doran	50	Brusher.
S6	Joseph	Moore	39	Brusher.

Injured

1	Henry	Allan	62	Repairer.
2	John Edwin	Birkett	51	Brusher.
3	Daniel	Hinde	41	Brusher.
4	John James	Weighman	24	Panpuller.

APPENDIX II

LIST OF WITNESSES

	Name	*Occupation*
1	Robert Wilson Gallantry	Surveyor.
2	Stephen Ferguson	Deputy.
3	Frederick Oliver Smith	Brusher.
4	Joseph McAleavy	Repairer.
5	Thomas Kervin	Repairer.
6	Henry Allan	Repairer.
7	William Hayton McAllister	Manager.
8	Andrew Roberts	H.M. Mines Medical Officer.
9	William McLaughlin	Haulage Hand.
10	John Edwin Birkett	Brusher.
11	Daniel Hinde	Brusher.
12	John James Weighman	Panpuller.
13	William Anderson Ashbridge	Overman.
14	Thomas Alver Edison Aitken	Deputy.
15	Thomas Edward Nicholson	Overman.
16	Norman Allan	Deputy.
17	Wilfred Kirk	Overman.
18	Wilson Graham	Deputy.
19	Henry Cherry	Deputy.
20	James Doran Lynch	Deputy.
21	Thomas Harrison	Borer.
22	William Anthony Armstrong	Borer.
23	David Coward	Filler.
24	Gregory Ferguson	Deputy.
25	George Henry Jackson	Deputy.
26	William Dockerty	Deputy.
27	John Arthur Milligan	Repairer.
28	Claude Bernard Meister Platt	Superintending Testing Officer.
29	George Douglas Nussey	H.M. District Inspector of Mines.
30	William Jesse Badger	H.M. Assistant Inspector of Mines.
31	Duncan Davie	H.M. Assistant Inspector of Mines.
32	James Bell	Inspector of Police.
33	William Durham	Inspector of Police.
34	Robert Noel Forster	H.M. Assistant Inspector of Mines.
35	Frederick Thomas Hindley	H.M. Assistant Elec. Inspector of Mines.
36	Harold Charlesworth Grimshaw	Principal Scientific Officer.
37	Frederick Vincent Tideswell	Senior Principal Scientific Officer.
38	Fred Stephenson Wellington Kirk	Ventilation Engineer.
39	William Storey	Magazine Attendant.
40	James Garton Gallagher	Lamproom Attendant.
41	Ivan George Elmer Leek	Rescue Apparatus Testing Officer.
42	Charles Clare	Compressor and Fan Attendant.
43	Daniel McPherson	Agent.
44	Joseph Ivon Graham	Scientific Advisory Officer, N.C.B.
45	Joseph Garside Helps	Area General Manager.
46	George Price	Consulting Mining Engineer.

APPENDIX III

CAUSES OF DEATH OF 104 MEN KILLED IN WILLIAM PIT GROUPED INTO SEVEN AREAS.

Area		No. of men killed in area	Cause of death
1	On Inbye side of No. 3 Air Crossing	45	All CO. No. 5 sustained a fractured skull.
2	Main return—between Nos. 2 and 3 Thirls.	4	All violence and extensive burns.
3	No. 3 Junction and its immediate vicinity.	16	6 Violence + Burns. Nos. 52, 54, 55, 56, 57 and 101. 10 CO + Burns.
4	No. 2 Dip Face	25	24 CO + Burns. 1 Violence + Burns. No. S.3.
5	Near Junction No. 2 Dip Trunk Road with Conveyor Road leading to Back-end Shortwall.	10	9 CO + Burns. 1 Violence + Burns. No 129.
6	Back-end Shortwall Face	2	Violence + Burns
7	Main Return Airway Outbye ..	2	Carbon Monoxide.

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